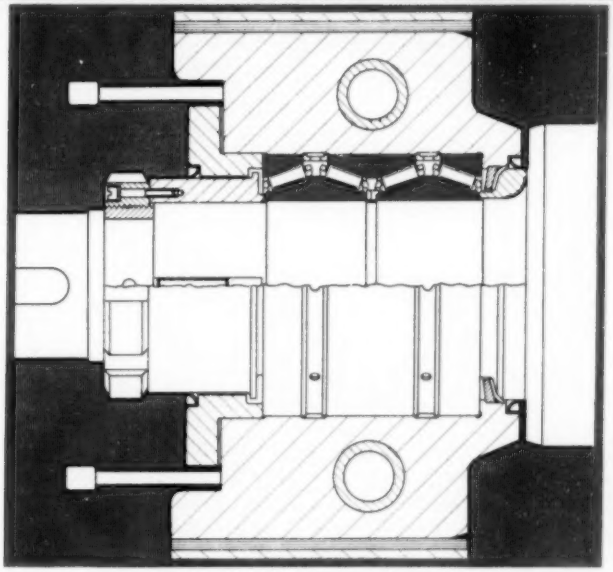
Sheet Metal Industries

The only Journal in the World wholly devoted to the Manufacture, Manipulation, Fabrication, Welding, Assembly and Finishing of Ferrous and Non-Ferrous Sheet and Strip

VOL. 37 : No. 396 APRIL 1960 PRICE 2/6



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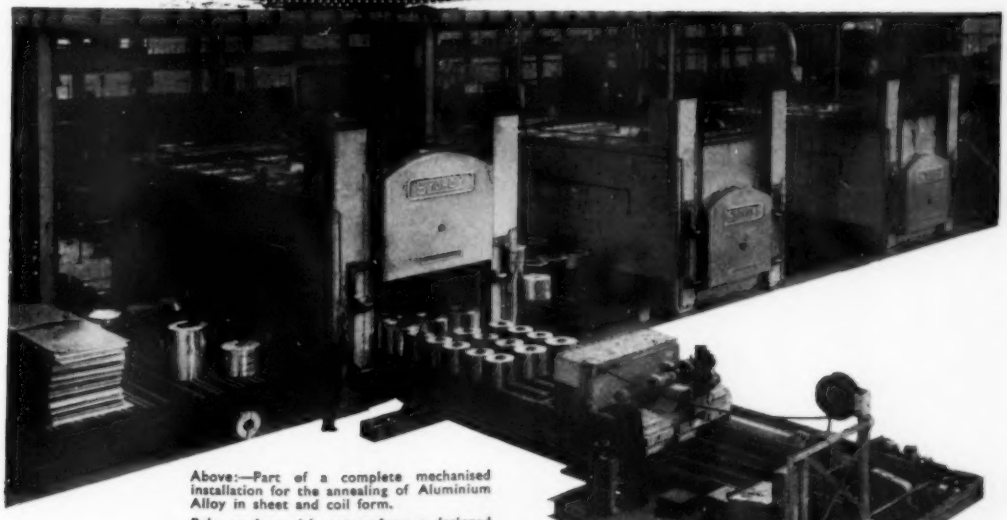

Above:—Part of a complete mechanised installation for the annealing of Aluminium Alloy in sheet and coil form.

Below:—A special-purpose furnace designed for the rapid annealing of Aluminium Alloy sheets and circles.

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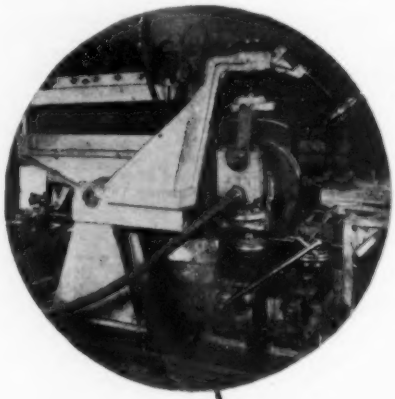
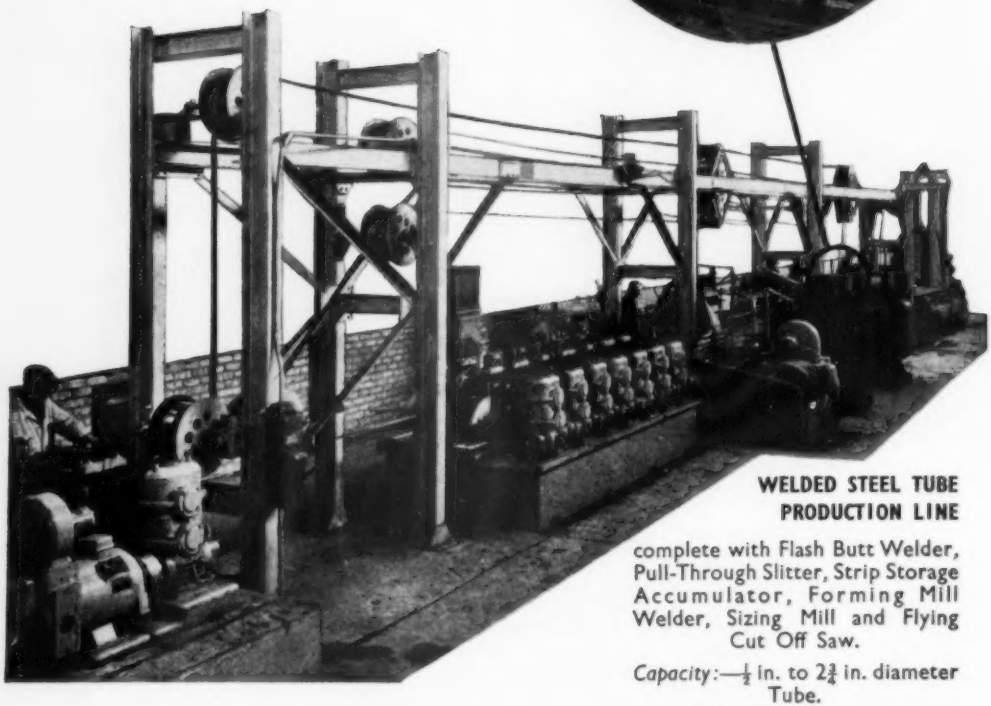
Classified Advertisement pages. 111

ARM

Close-up of Welding Unit





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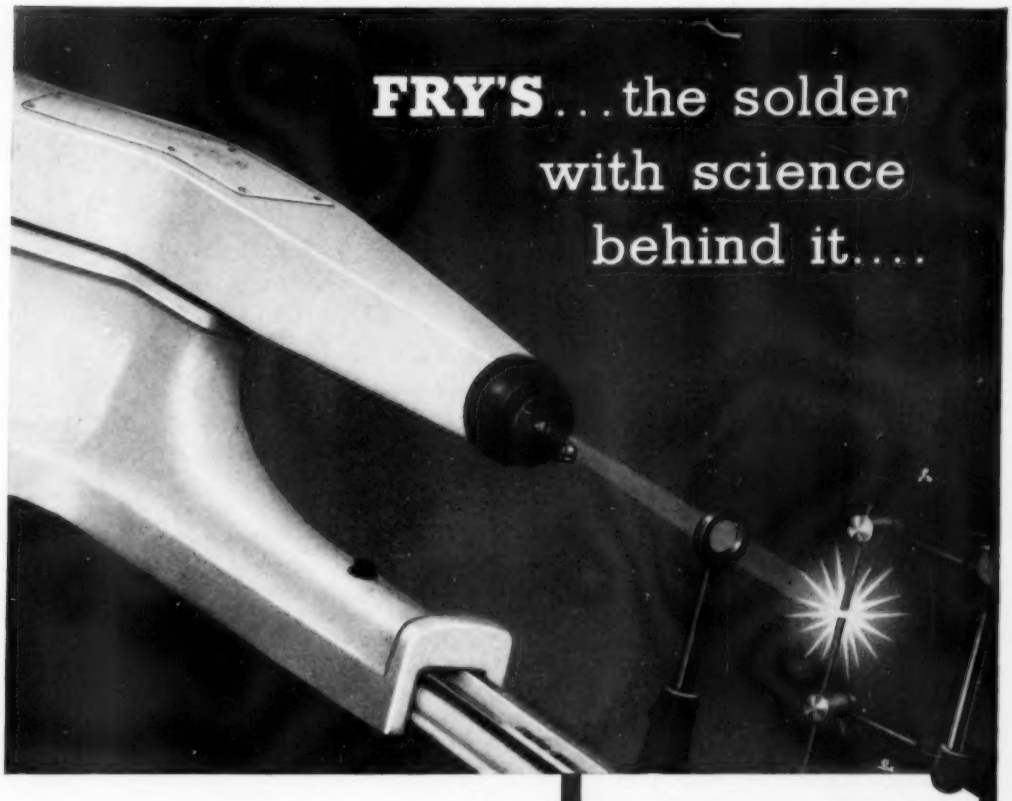

This is a routine spectrographic test carried out on every batch of FRY'S solder which leaves the works.

The spectrographic test detects harmful impurities which could mean gritty solders causing weak or brittle joints.

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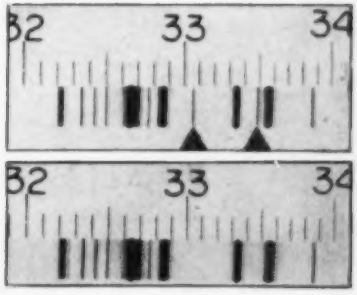

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Spectrographic Tests Prove it!

In this top print the fine lines (arrowed) show zinc impurities which mar performance. The print below is free from contaminating impurities typifying FRY'S solders.

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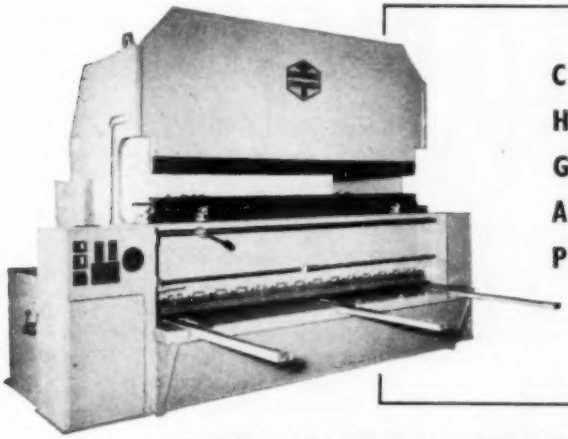

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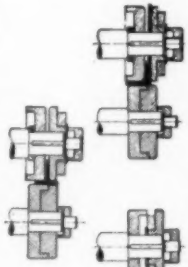
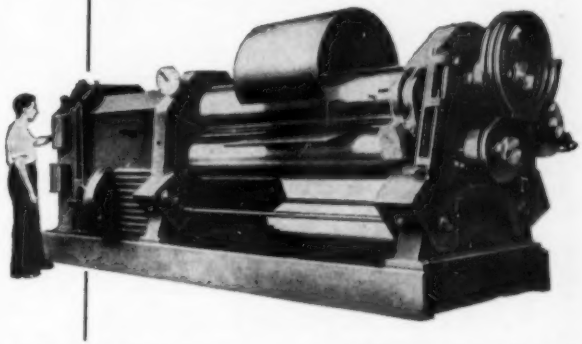
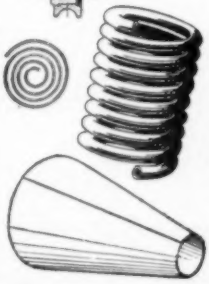


COMBINED PLATE AND SECTION BENDING ROLL OF INITIAL PINCH TYPE





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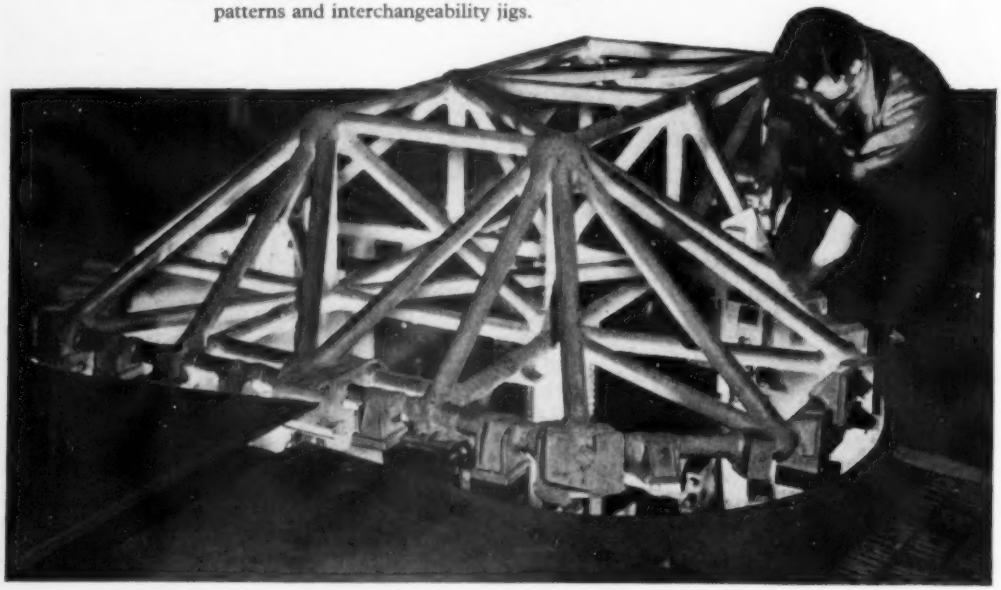

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MOON STAR

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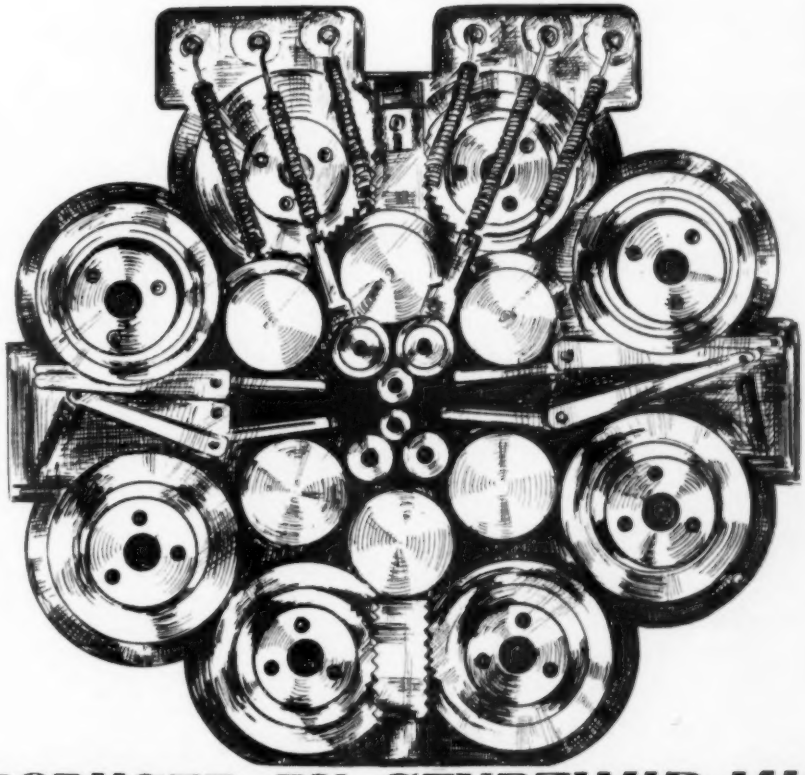

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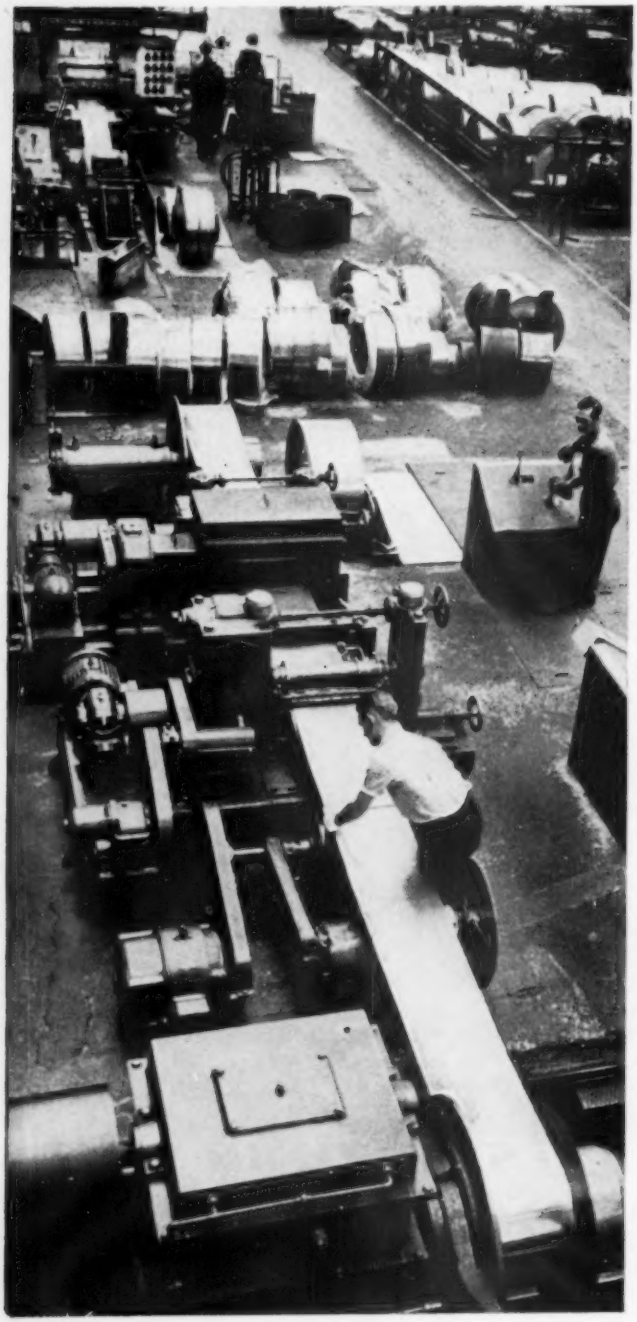

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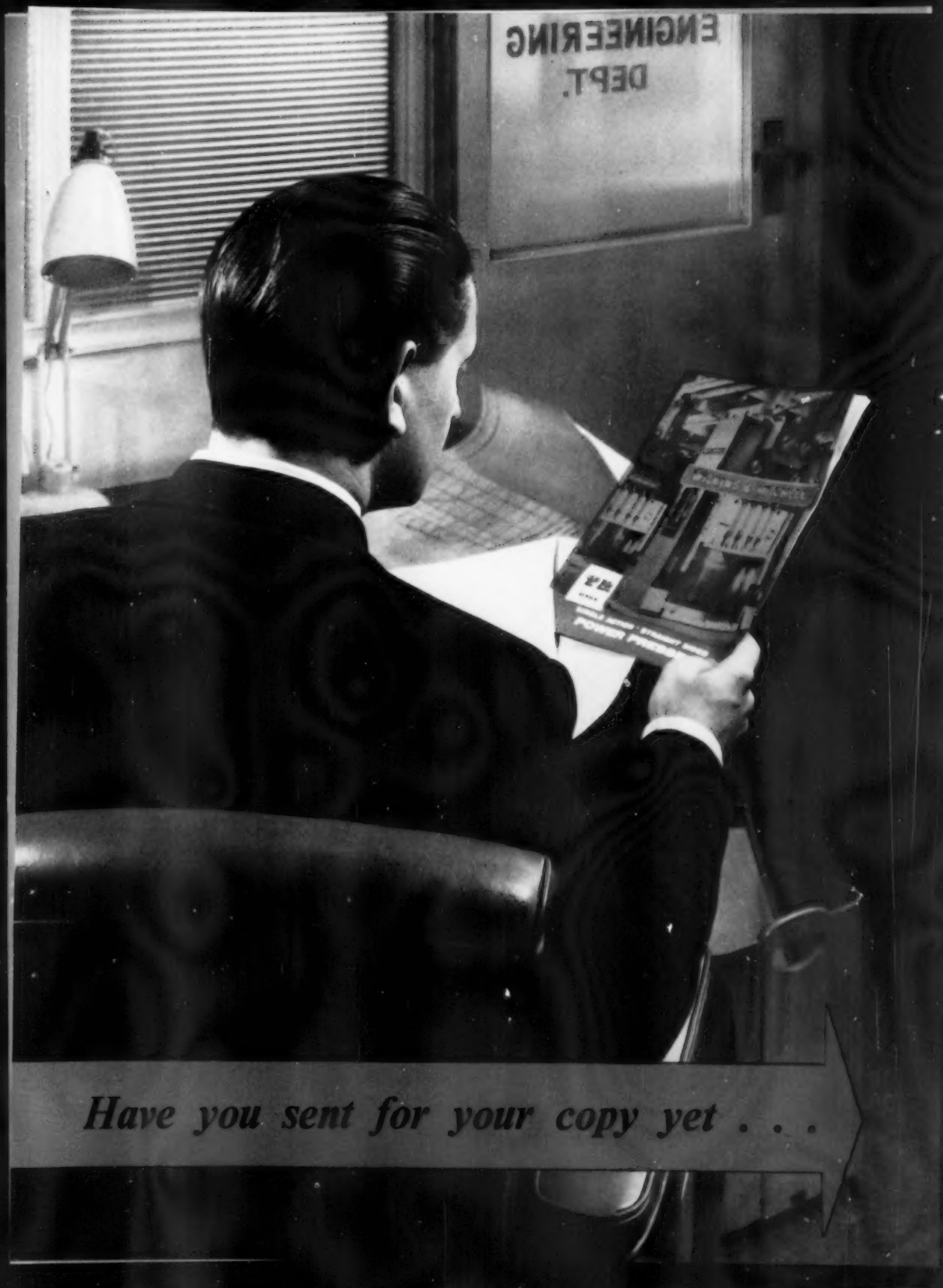
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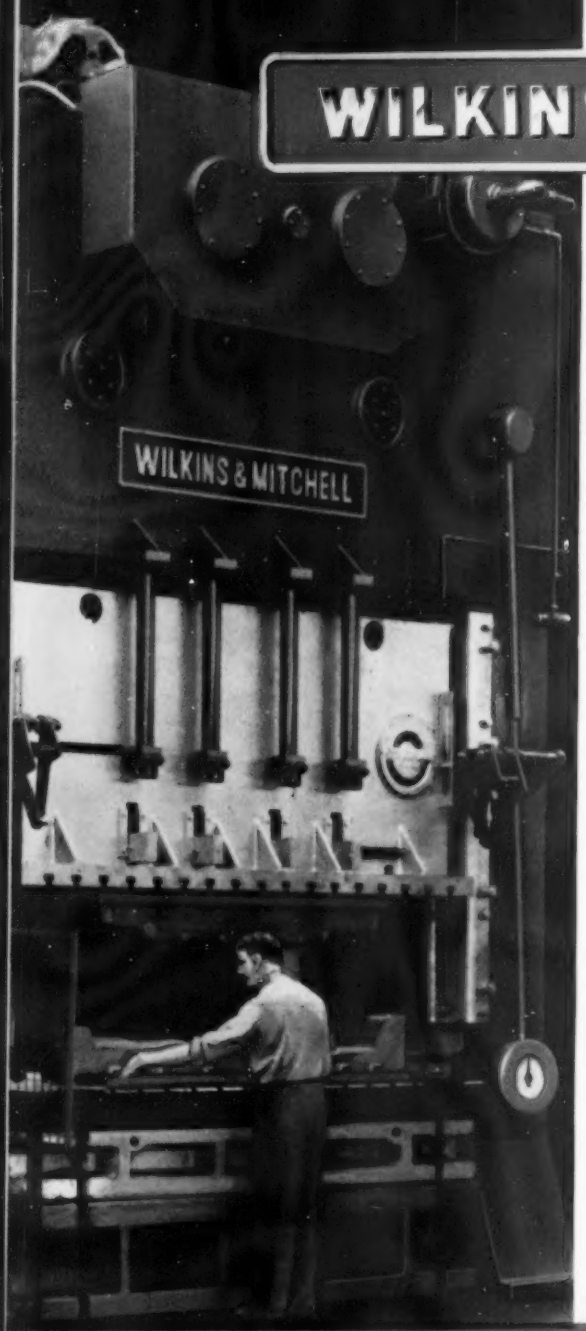

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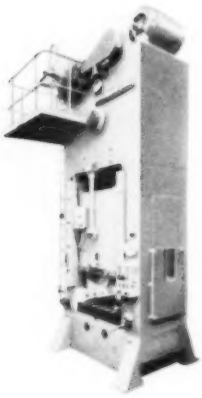

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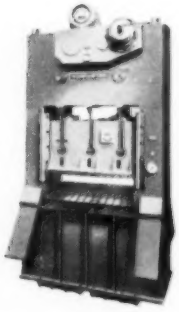

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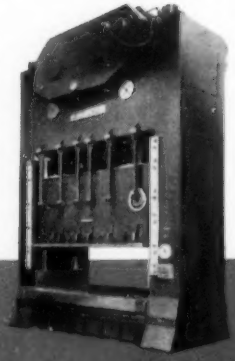

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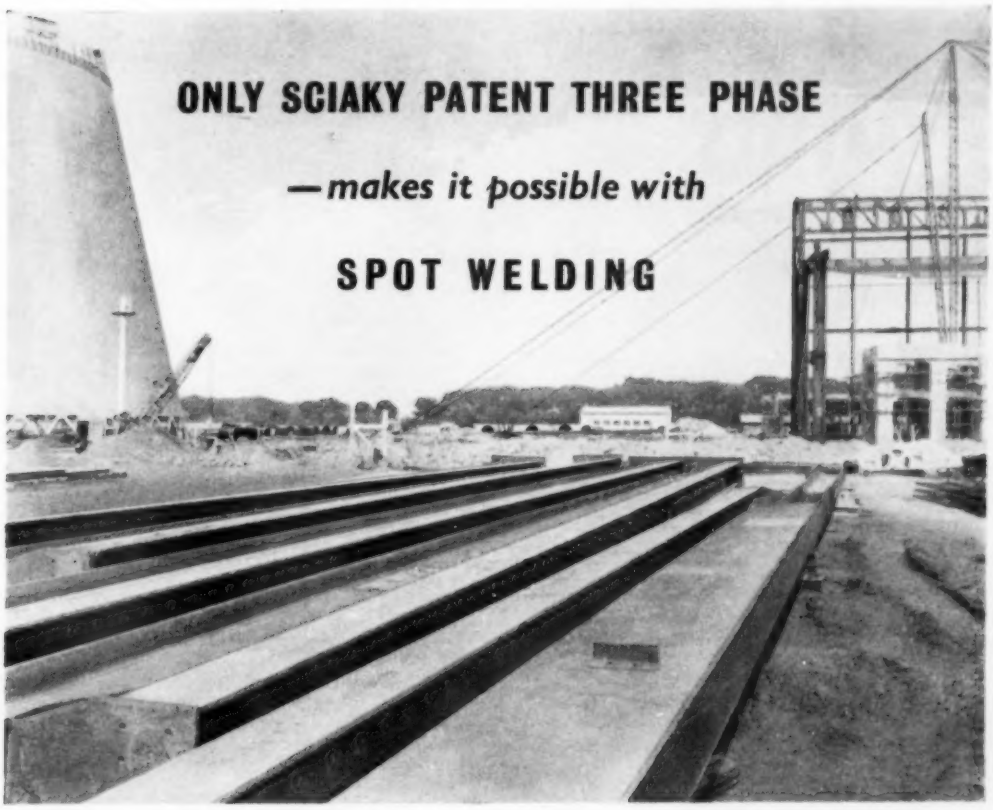

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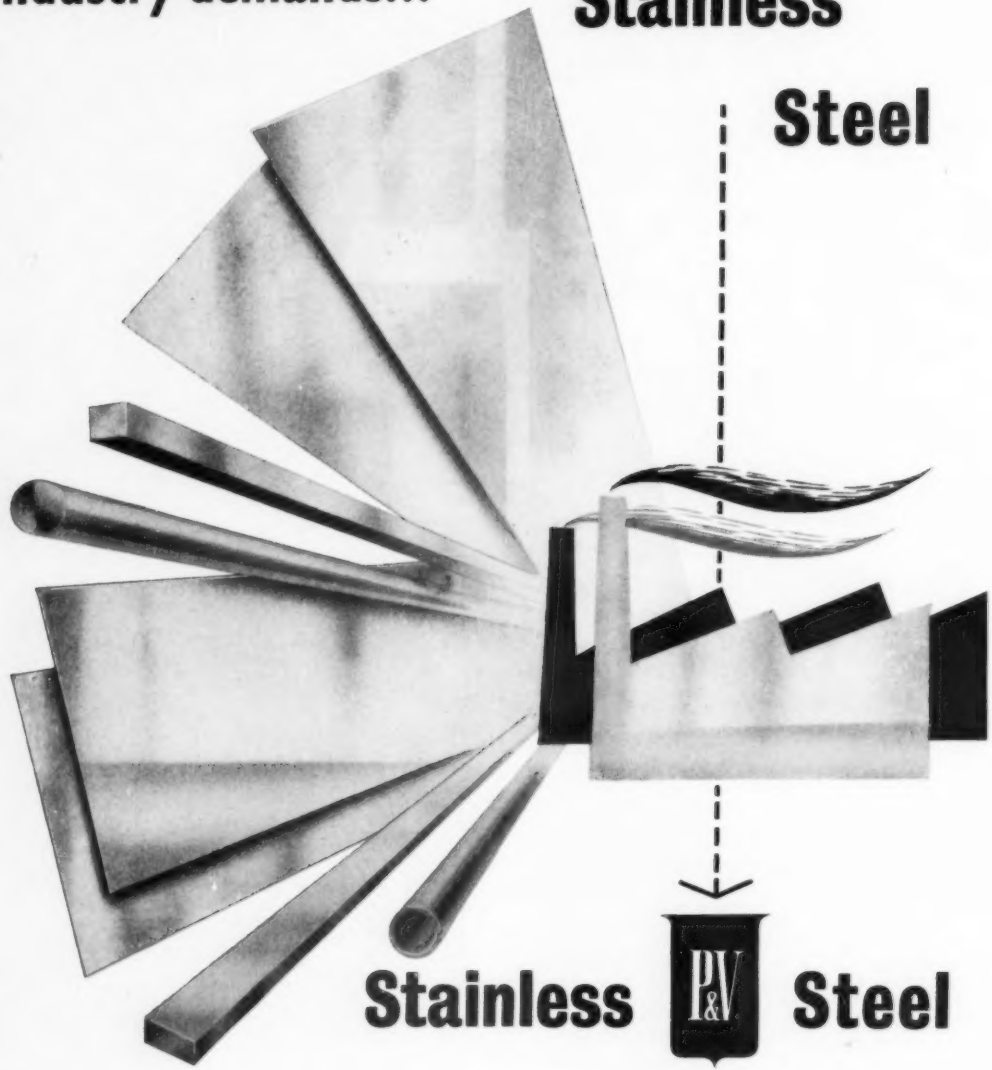

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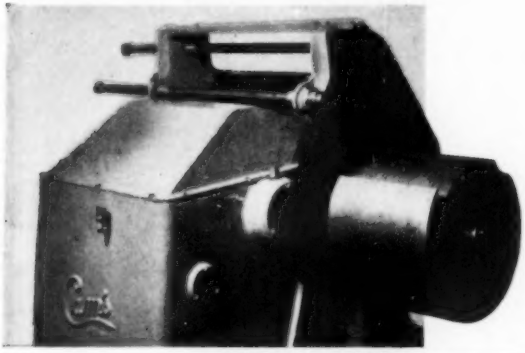

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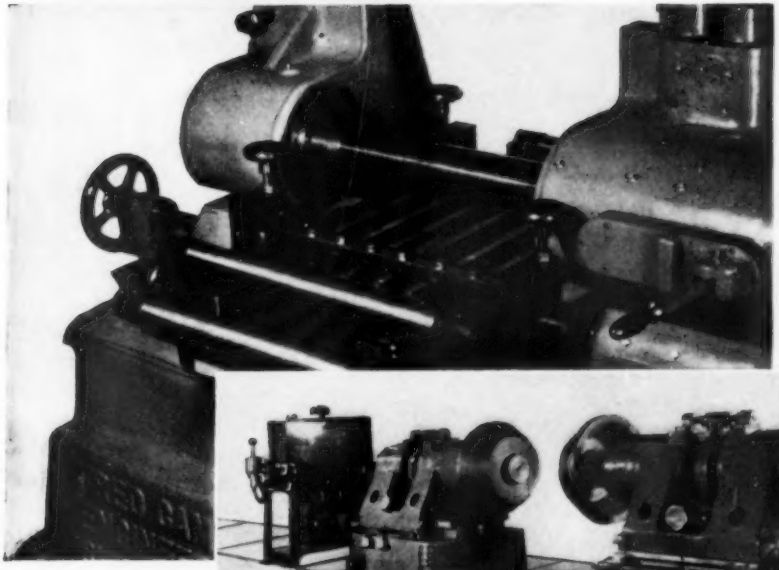

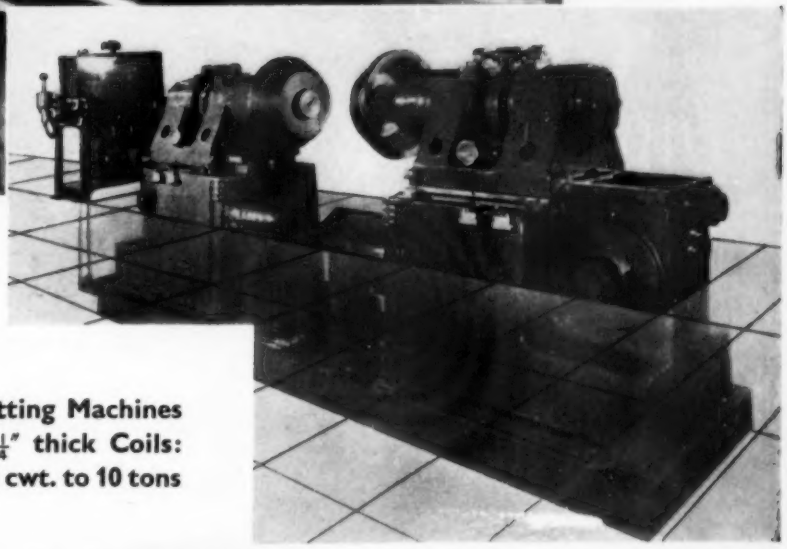

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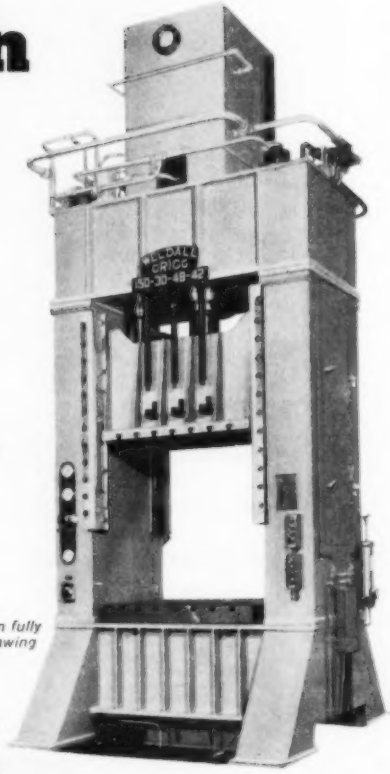

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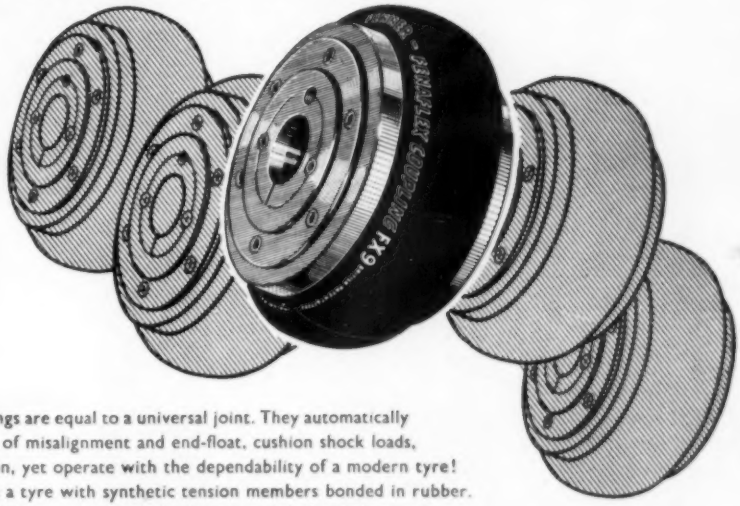

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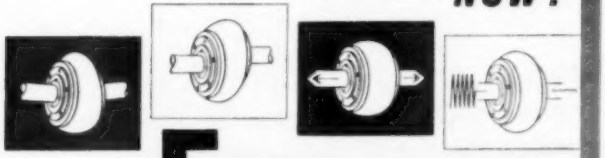

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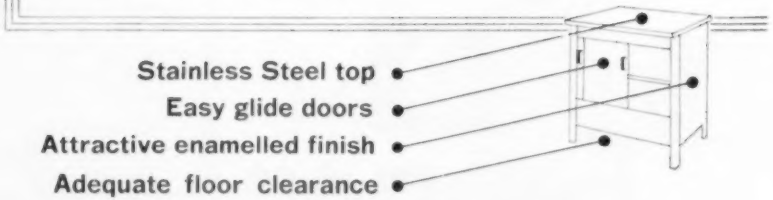

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'Artbrite' sheets are RTB M.S. sheets (protected by hot-dip 'Speltafast' galvanizing or by lacquering) with a closely-adherent 10 thou. coating of P.V.C. film.

Available in many luxury finishes, glossy, matt, and various textures, and in a wide range of colours, the coating is resistant to abrasion and to a great many chemicals. 'Artbrite' sheets on the 'Speltafast' base are fully weather-resistant.

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This cupping test piece shows the elasticity and adhesion of the P.V.C. coating, and retention of the surface texture.

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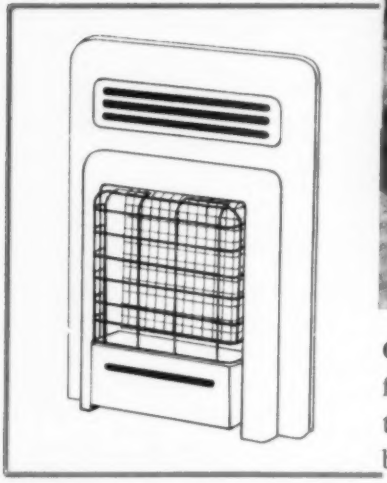
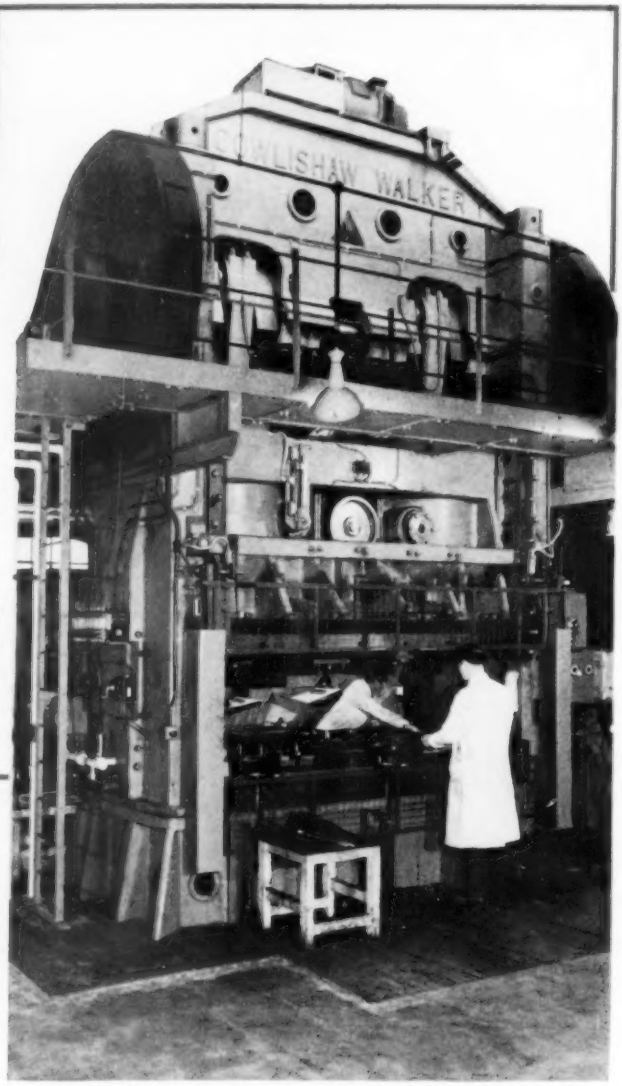
400 TON PRESS

Producing outer casings for the famous range of Bratt Colbran gas fires at their Wembley works.

This advanced and highly efficient design of gas fire sends convected warm air to every corner of the room in addition to the normal radiant heat.





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Some of the advantages of "ALUDIP"

HEAT RESISTANCE — **"ALUDIP"** is the only coated steel on the market in its price range offering **Efficient Protection** up to temperatures of 700/750° C.

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FINISH — No further protective finish other than decorative, need be required.

Some of the uses of "ALUDIP"

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- Architectural construction; exterior and interior.
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THE PROCESS WHICH UNDOUBTEDLY FILLS A RECOGNISED NEED FOR A RELATIVELY LOW PRICE HEAT RESISTING AND CORROSIVE RESISTANT METAL

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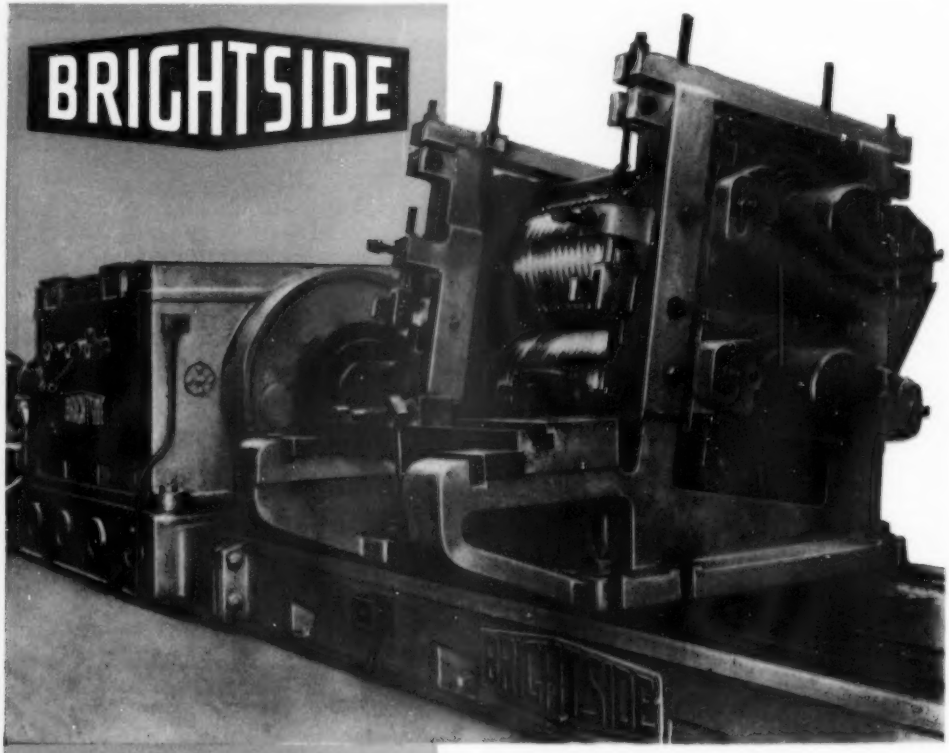

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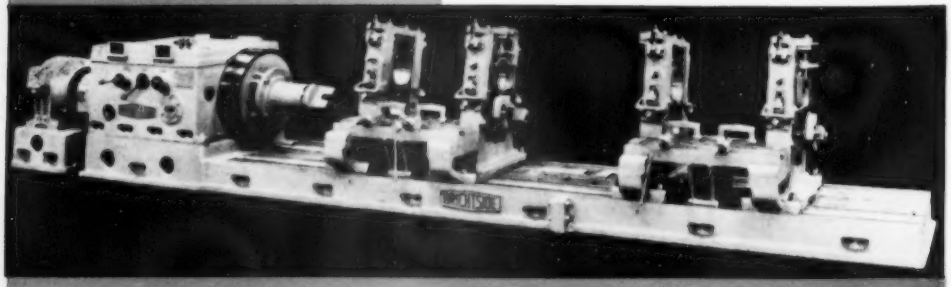

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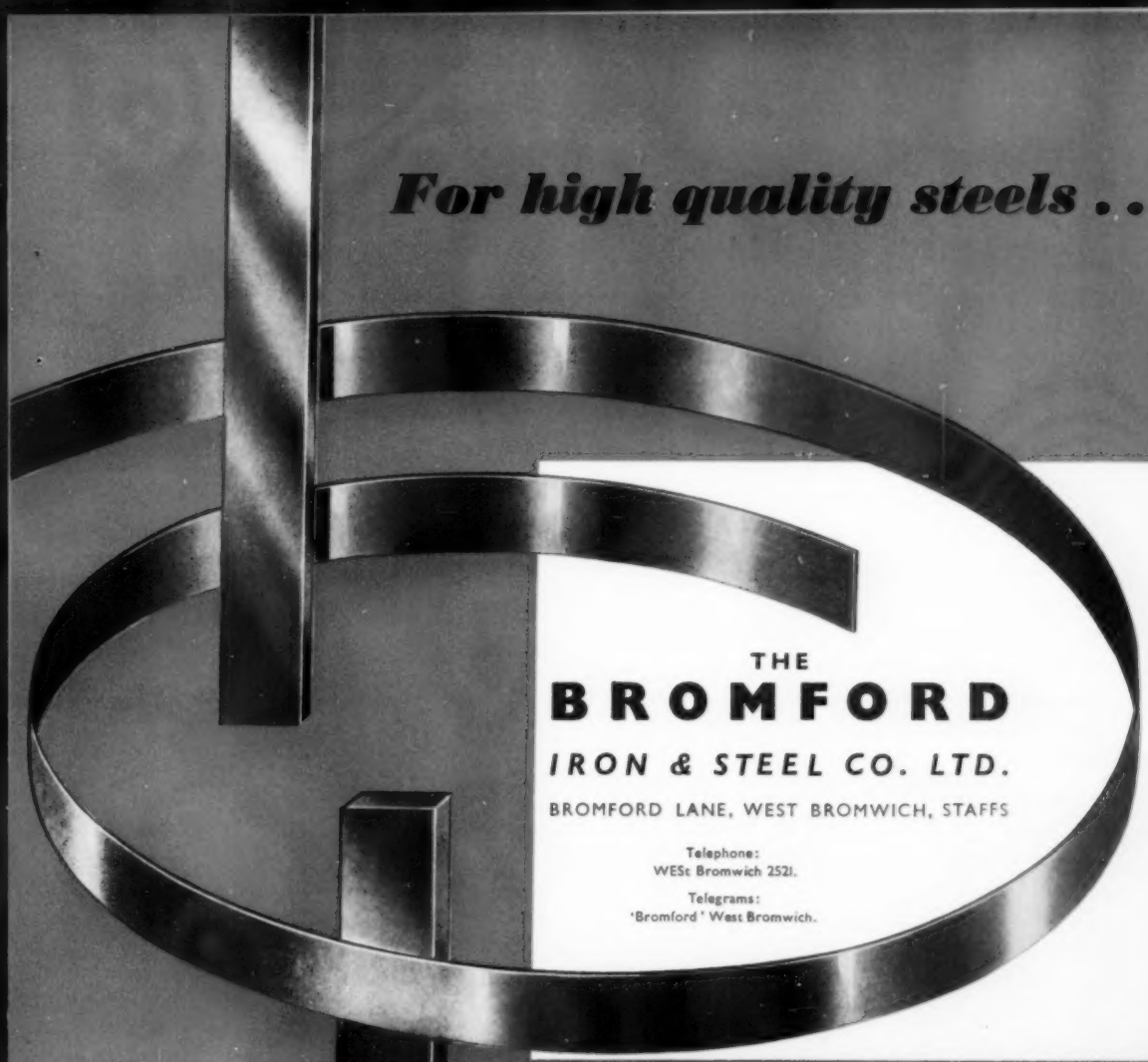

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Sizes: ⅜" to 3½" wide, 16 gauge to ⅜" thick. In coils or lengths.

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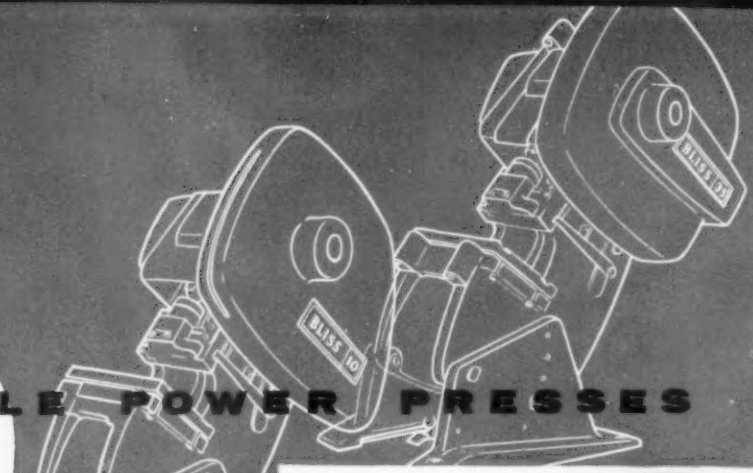

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10 FLYWHEEL

15 FLYWHEEL

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35 FLYWHEEL GEARED

45 FLYWHEEL GEARED

60 FLYWHEEL GEARED

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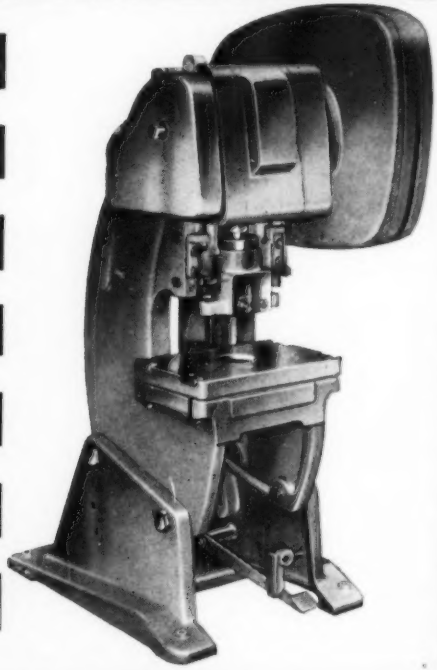

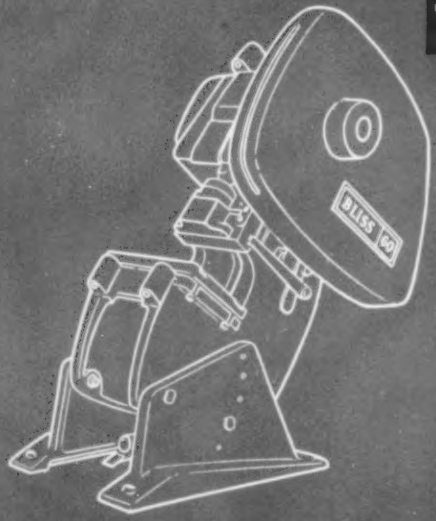

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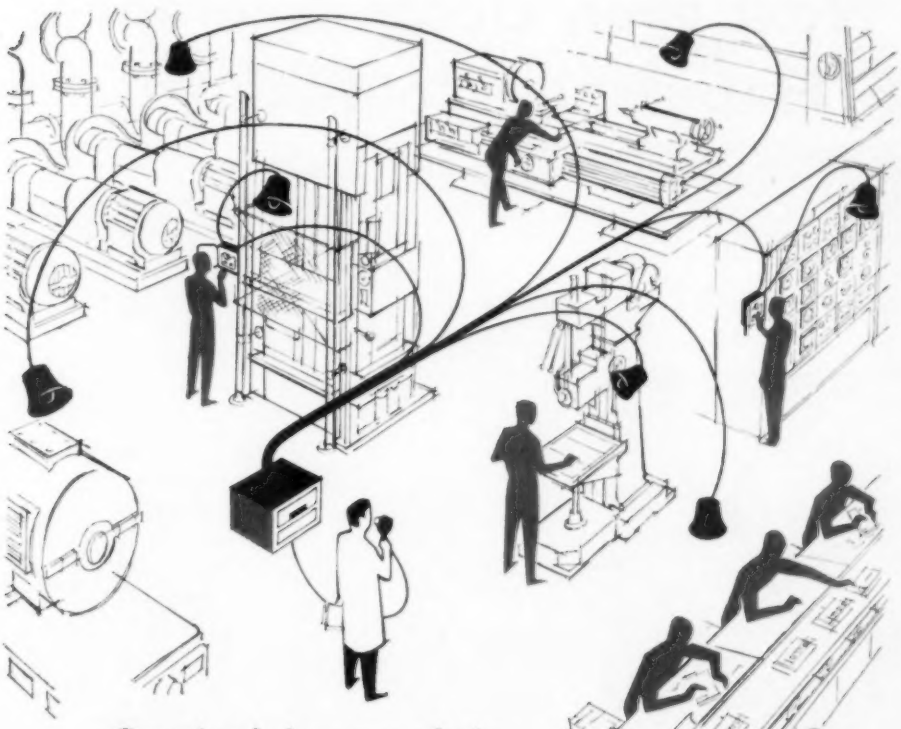

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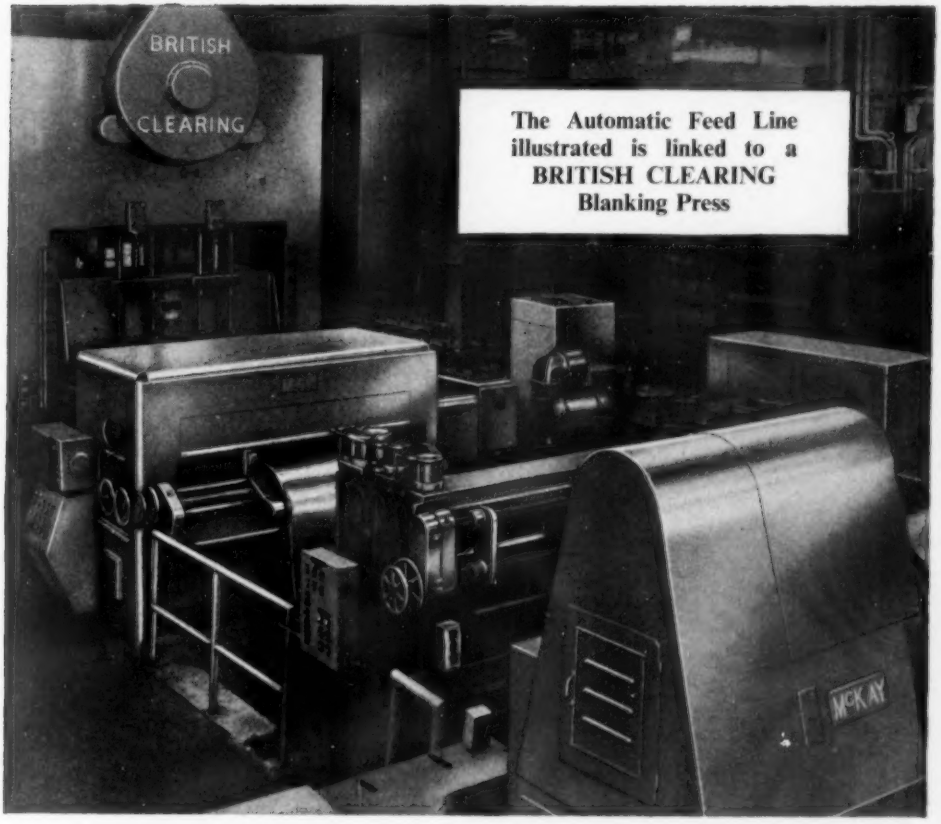
McKAY Automatic Feed Lines

for *Decoiling, Straightening, Washing etc*



The Automatic Feed Line illustrated is linked to a BRITISH CLEARING Blanking Press

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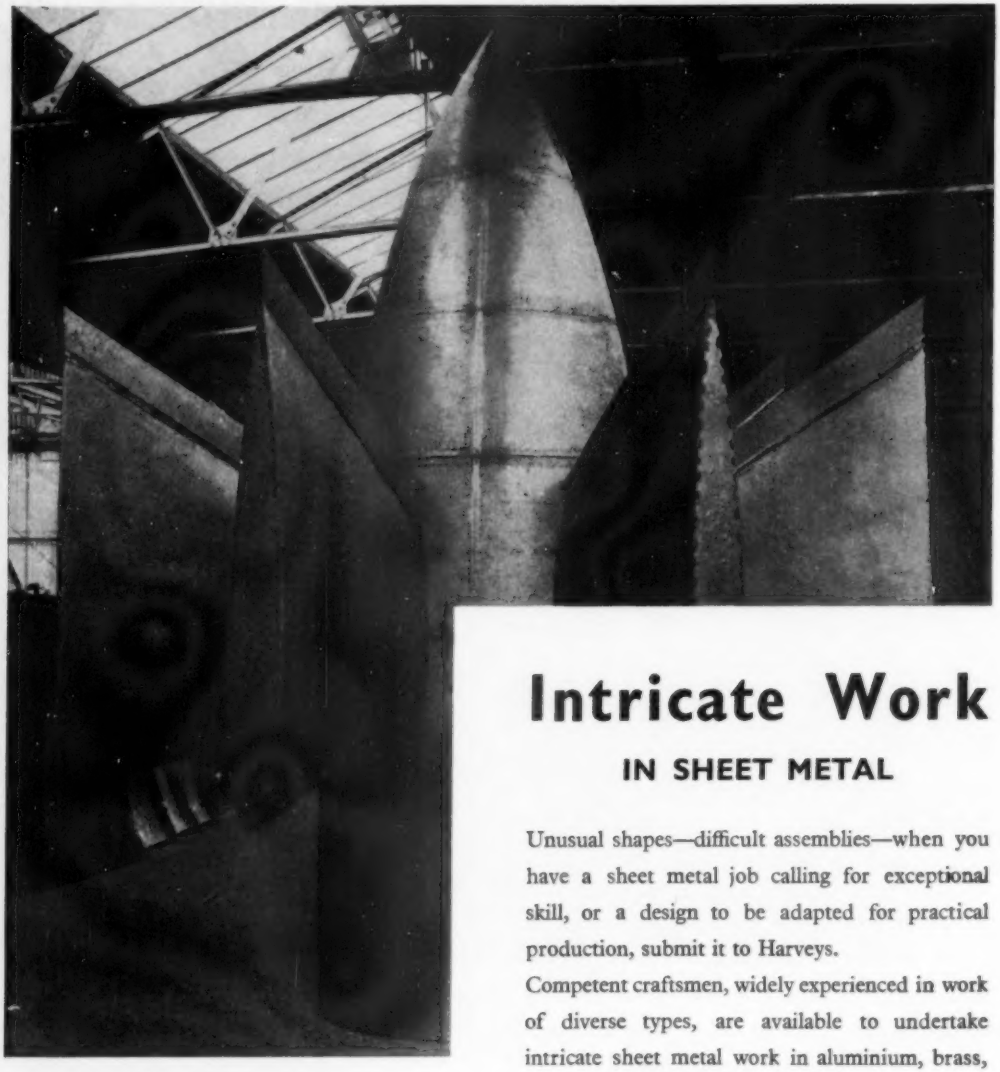

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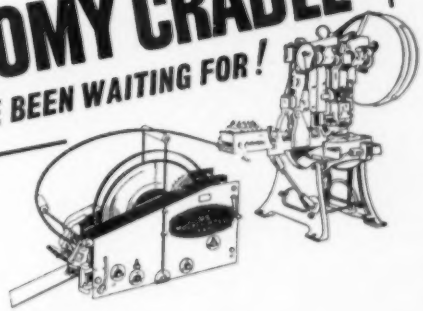
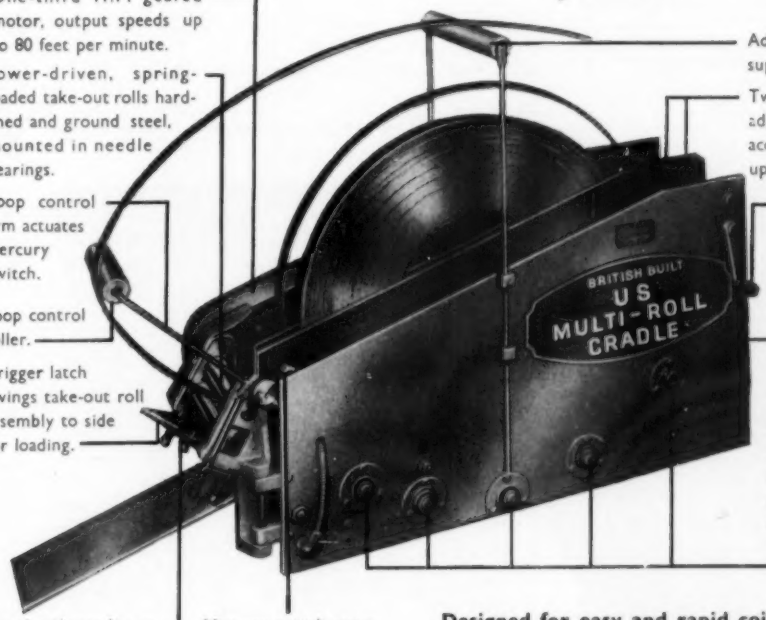
MULTI-ROLL ECONOMY CRADLE

THIS IS THE CRADLE *at the price* YOU'VE BEEN WAITING FOR!





One-third H.P. geared motor, output speeds up to 80 feet per minute.

Power-driven, spring-loaded take-out rolls hardened and ground steel, mounted in needle bearings.

Loop control arm actuates mercury switch.

Loop control roller.

Trigger latch swings take-out roll assembly to side for loading.

Quick release lever facilitates threading of take-out rolls.

Mercury switch automatically starts and stops motor.

Adjustable loop supporting roller.

Two inner frames adjustable individually to accommodate stock widths up to 9".

Hand cranks for adjusting inner frames to suit width of coil. Also centre line of coil.

Two sturdy outer frames.

Five coil rest rollers (four power driven) in self-aligning bearings and arranged to equalize weight distribution.

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An AIRSCREW MINOR is economical, quickly fitted, reliable over long periods with very little maintenance; and *low in price.*

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No electrical interference.
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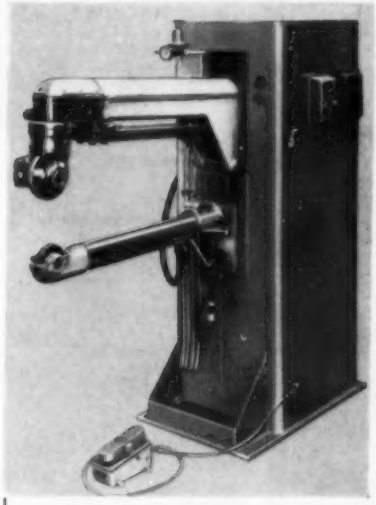
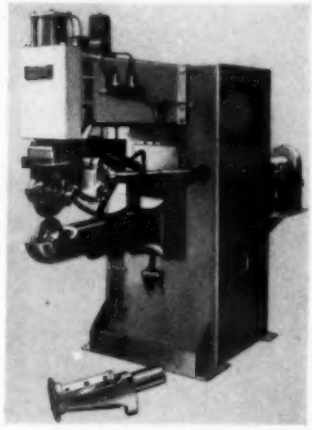
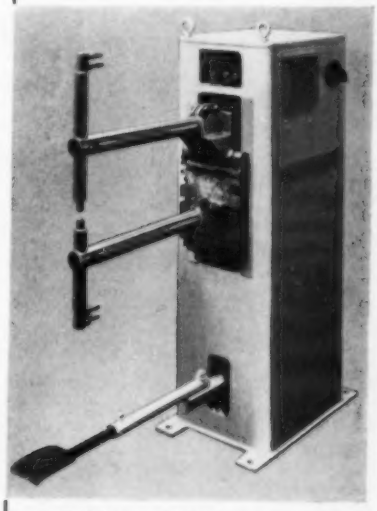


40 KVA Rocker arm type Universal Seam Welder.



Heavy duty 300 KVA Universal Seam Welding Machine with provision for step-by-step or roller spot welding.



Pedal operated Rocker arm type Spot Welder with electronic weld timer.

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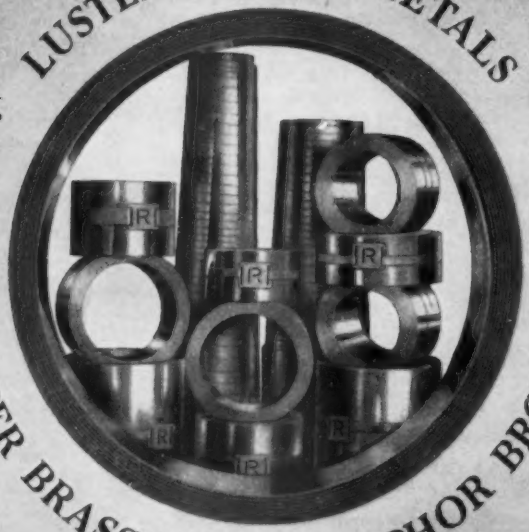

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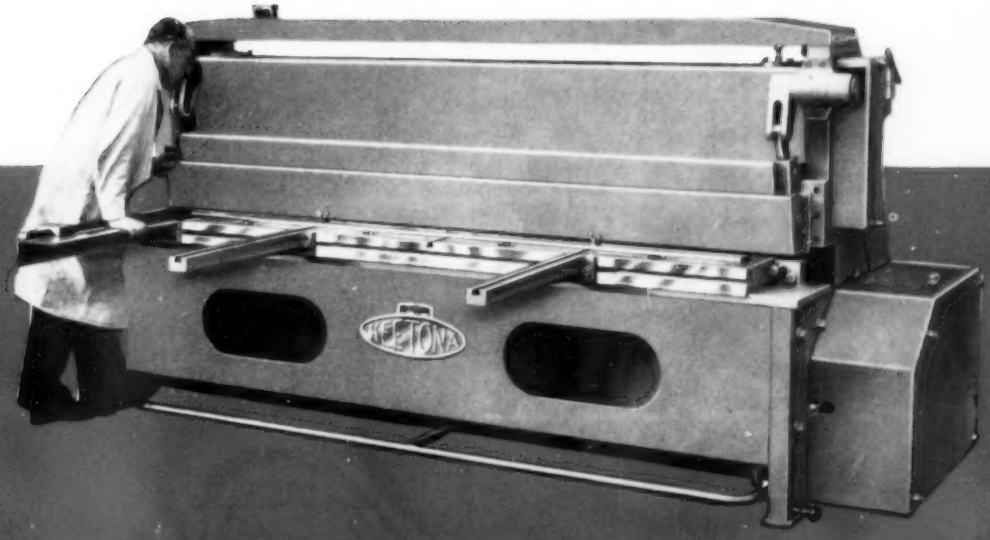

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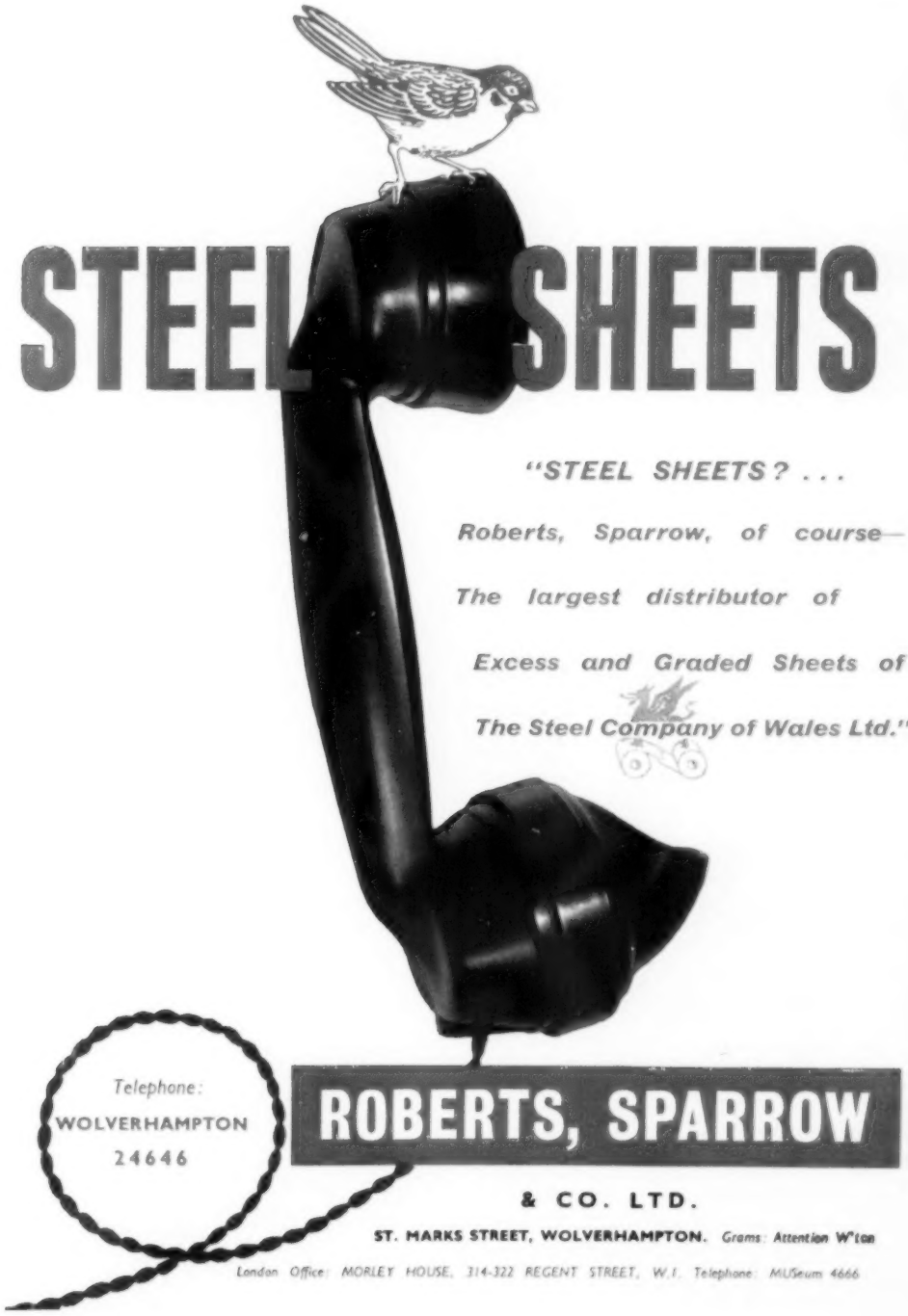

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The largest distributor of

Excess and Graded Sheets of

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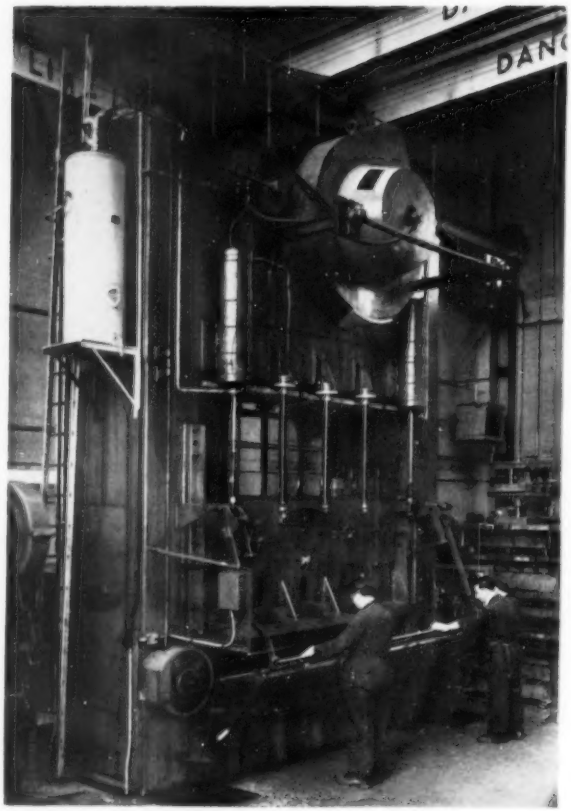

The illustration shows a 500 ton machine at Messrs. Turner Brothers (Birmingham) Ltd., to whom we are indebted for permission to use the photograph. Our Duocyclic drive is, however, applicable to a variety of sizes of our presses.

By means of a very simple and robust arrangement, two speeds are made available, allowing a considerable increase in productivity, whilst maintaining correct drawing speeds. In addition, should blanking jobs have to be undertaken, it is normally possible to use the fast speed only. The ratio between the speeds is usually 2 to 1, but higher ratios are used in certain cases.

The control of speed changing is by a number of switches arranged around a central cam and they can be adjusted very quickly to suit new jobs. This mechanism is protected by a transparent cover.

The press illustrated has bull wheel drive with exceptionally large pins, to keep bearing pressures low. Automatic high pressure lubrication is provided as standard, the pump motor being interlocked with the main driving motor.

A tie-rod four-piece safety frame is used on the machine shown and we also have available our solid steel all-welded frames. All of our frames are of exceptional rigidity and strength and, by manufacturing both types, we are able to recommend the most suitable design for each customer's requirements. The great depth of the slide is worthy of note, also the fact that it has very long narrow guides, giving correct support at all parts of the stroke.

An illustrated booklet of these presses is available and we shall welcome your enquiries for this and all other types of power presses.

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MACHINE TOOL CORPORATION LTD.

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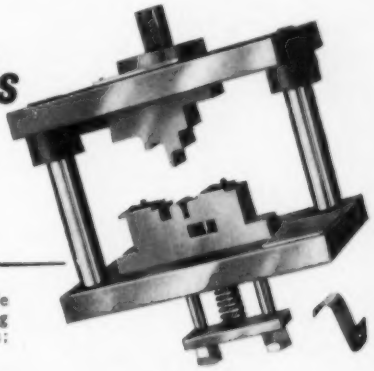
SANDERSON tool steels

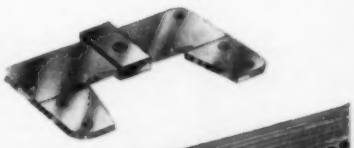
NEWHALL

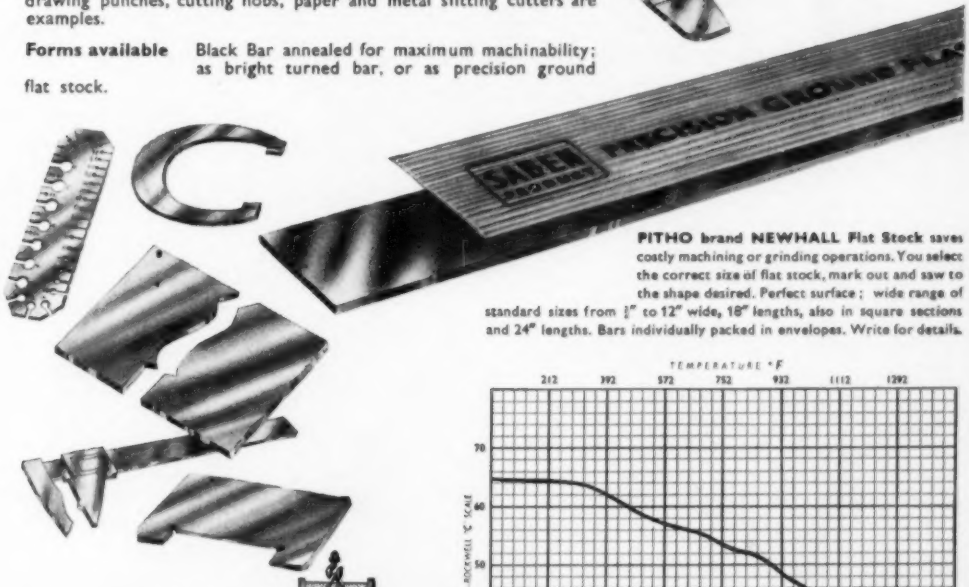


Characteristics Oil hardening chromium tungsten type high grade alloy tool steel. Non-deforming; wide hardening range gives latitude in heat treatment—760°/790° C. light sections; 790°/820° C. heavy sections.

Applications NEWHALL is suitable for numerous applications in which good wear-resistance and reliability in hardening are desired; broaches, bushes, machine parts, lathe centres, chuck jaws, master form tools, plug gauges, thread gauges and precision tools generally; cloth cutting knives, cold taps, reamers, collets, dies, drawing punches, cutting hobs, paper and metal slitting cutters are examples.

Forms available Black Bar annealed for maximum machinability; as bright turned bar, or as precision ground flat stock.





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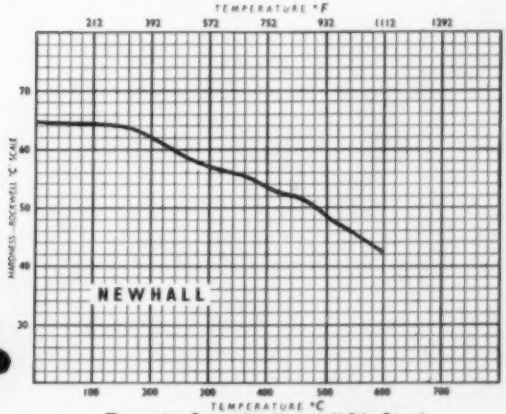

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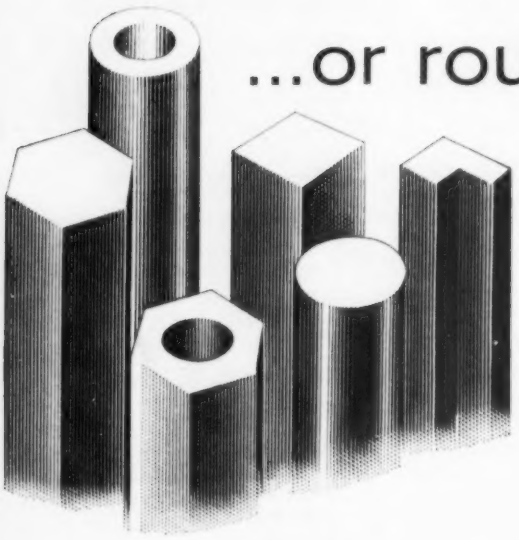

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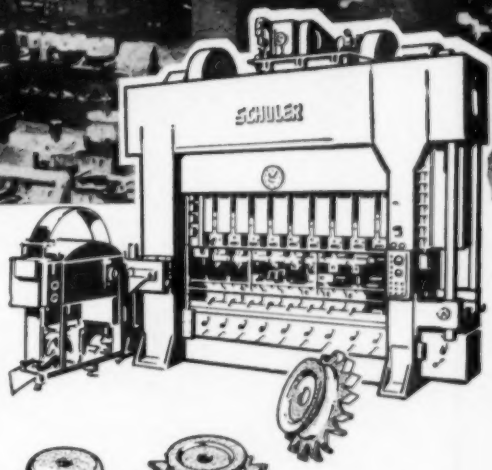

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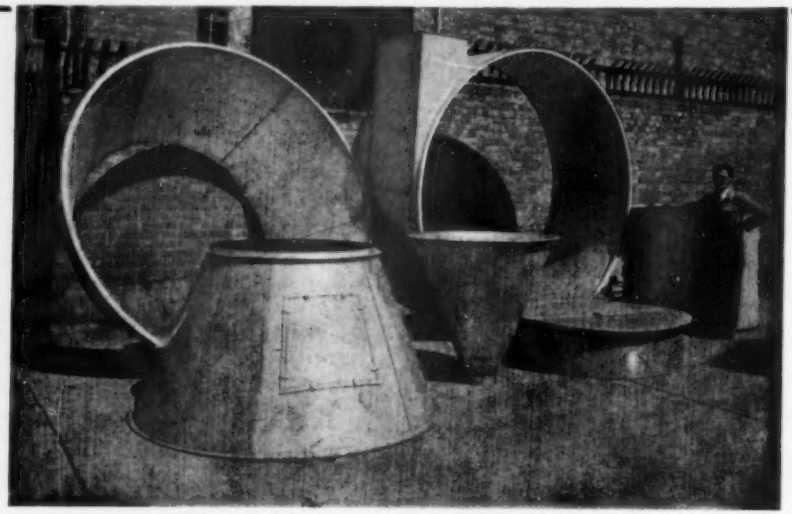

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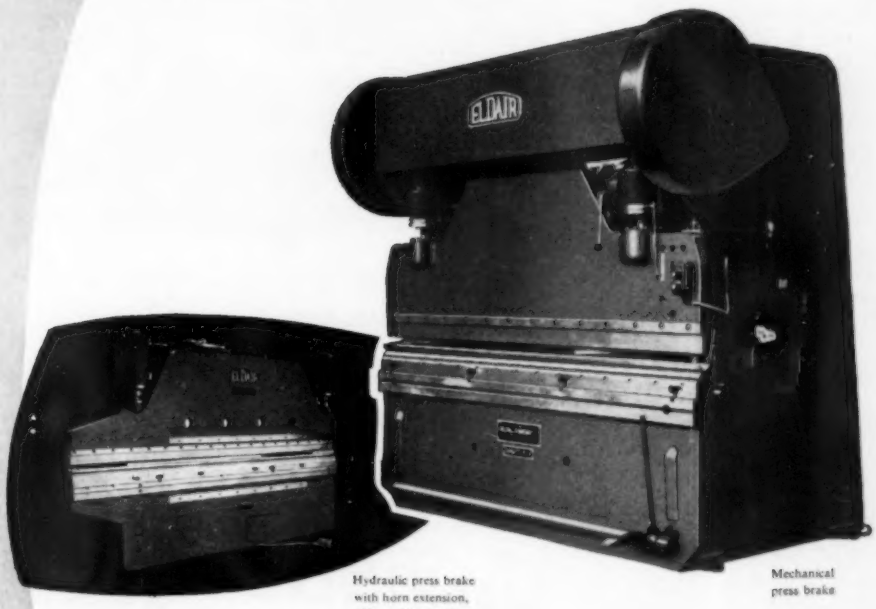

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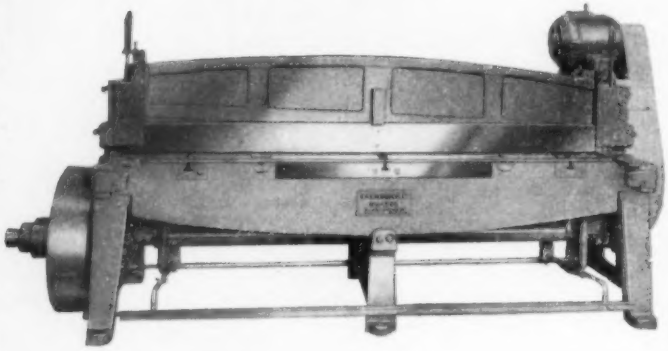

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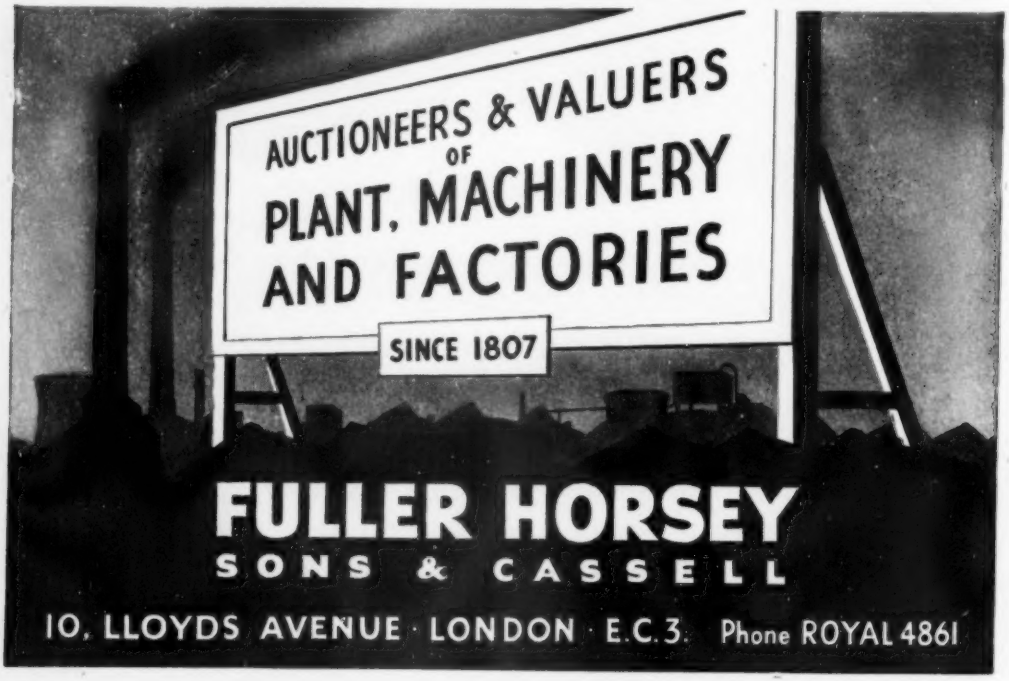

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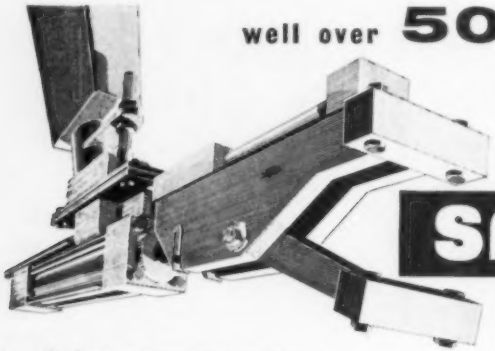

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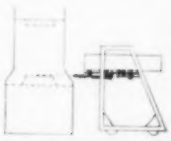

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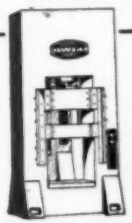

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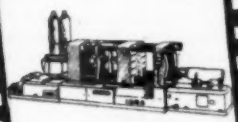

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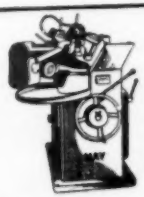

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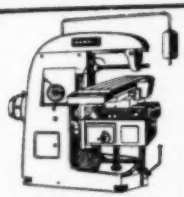

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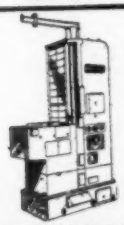

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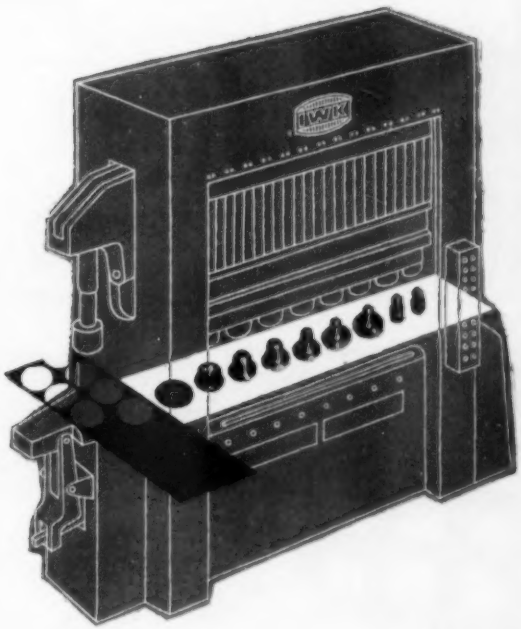

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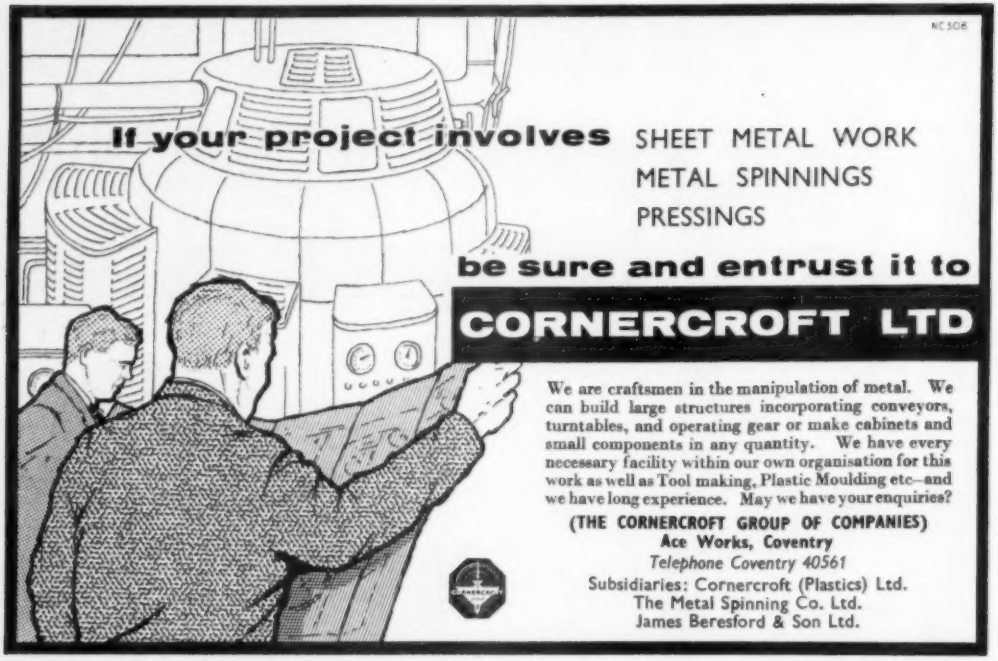
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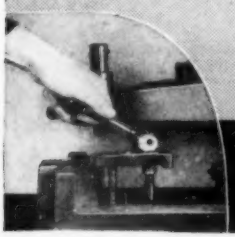

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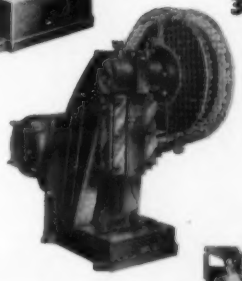
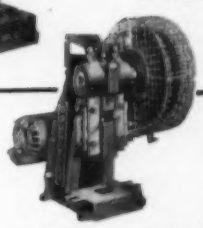


3 TON



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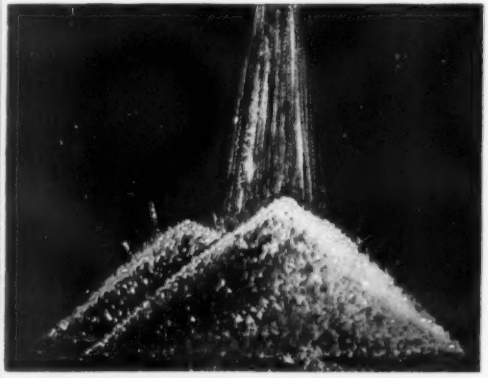

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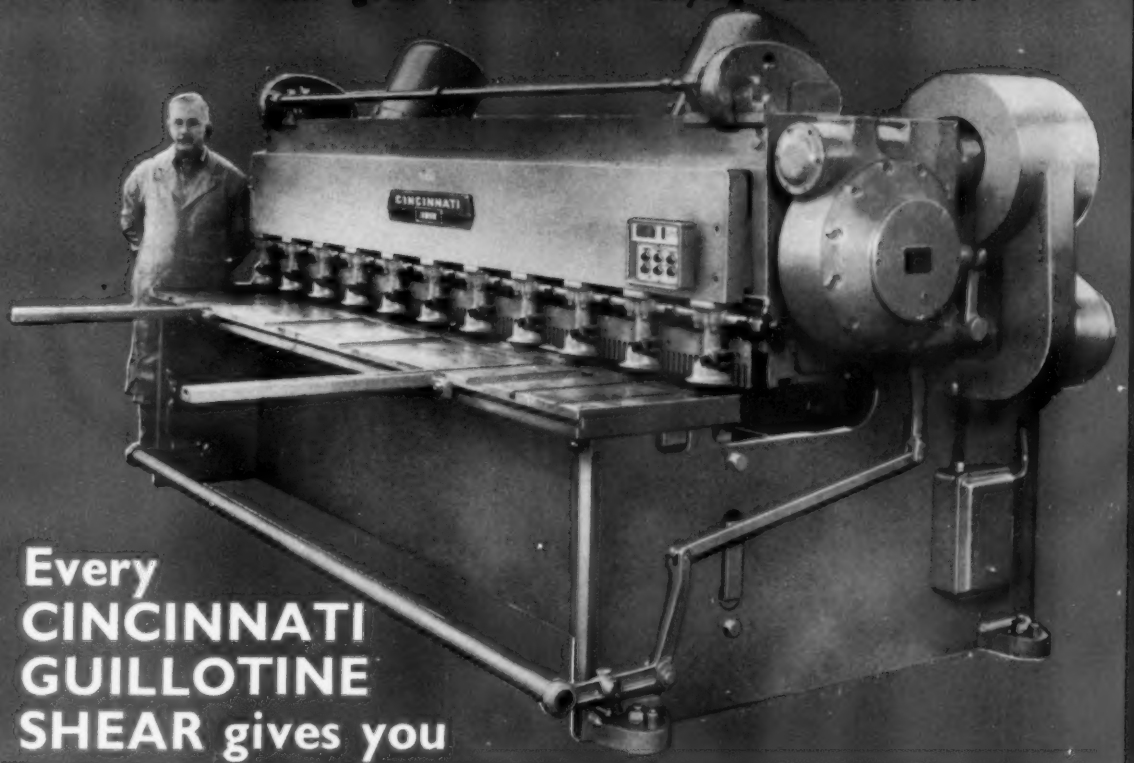

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3 BASIC ADVANTAGES

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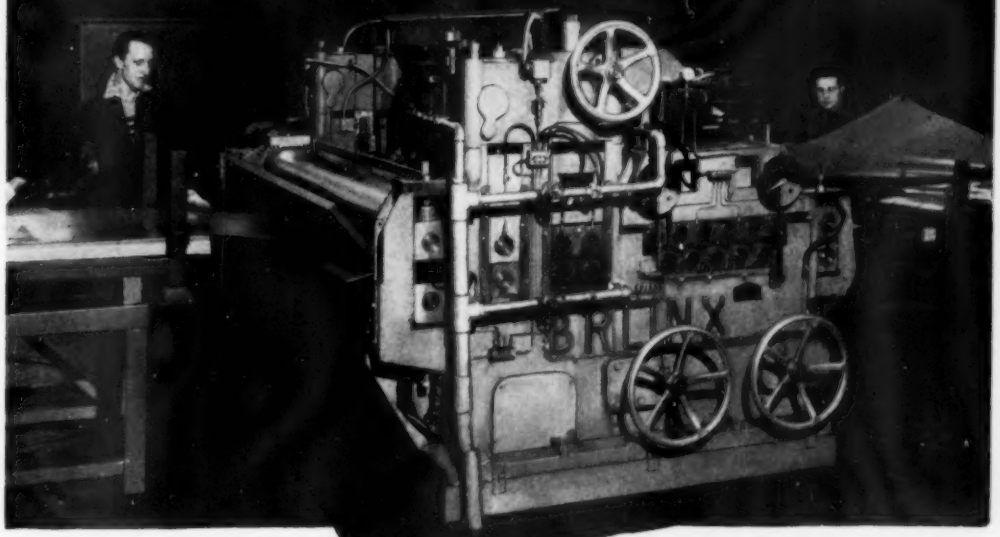

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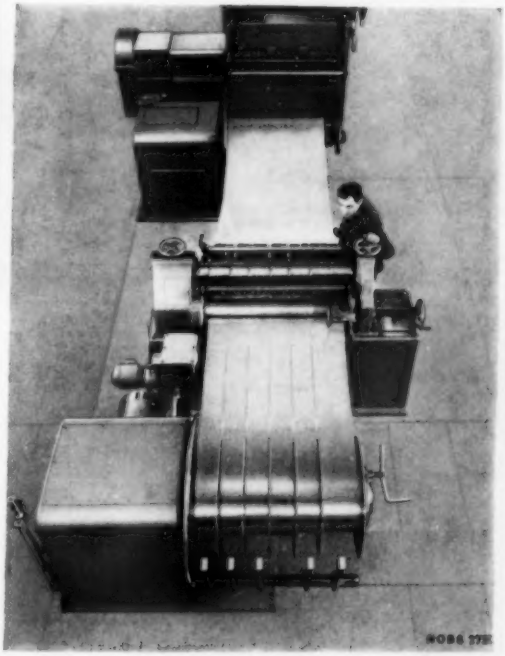

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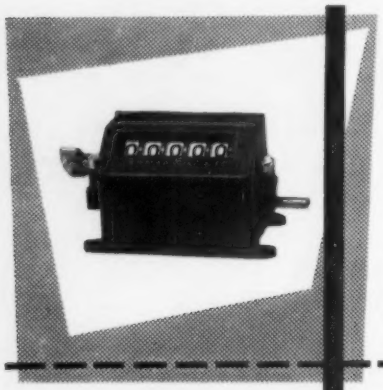

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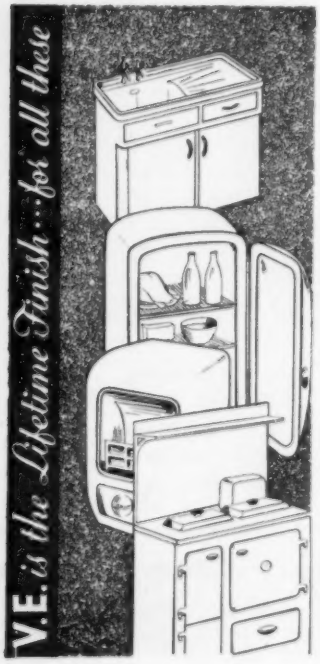

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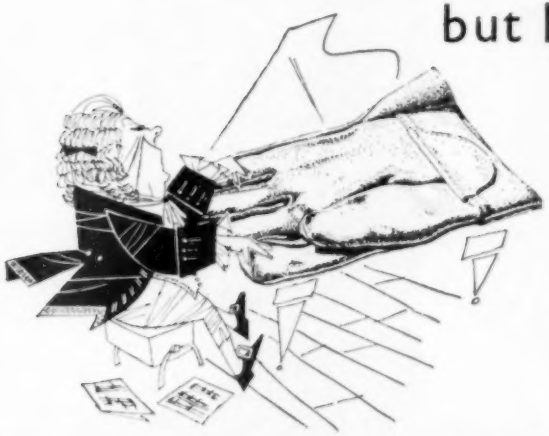

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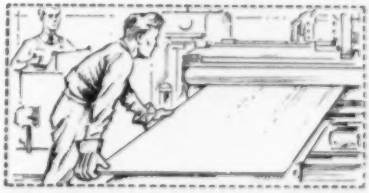

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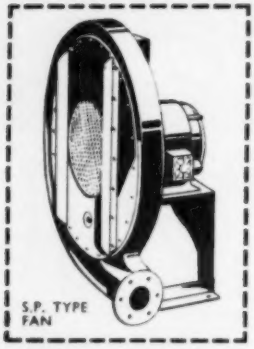

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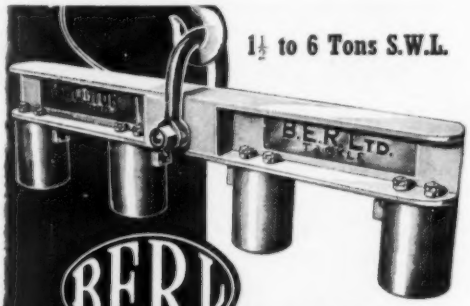

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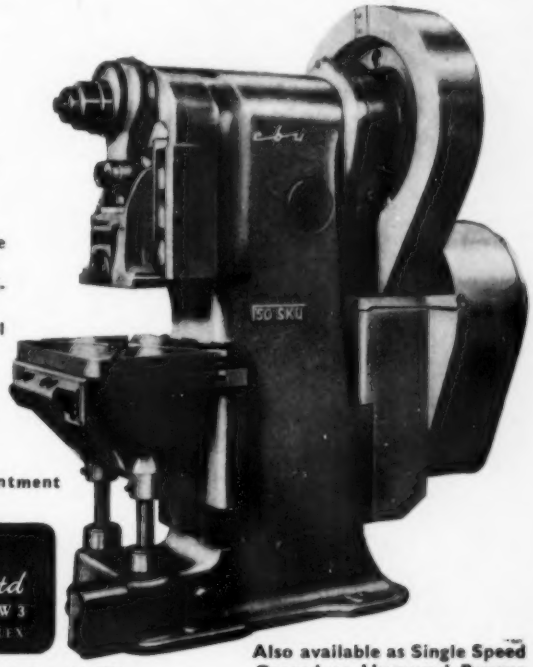

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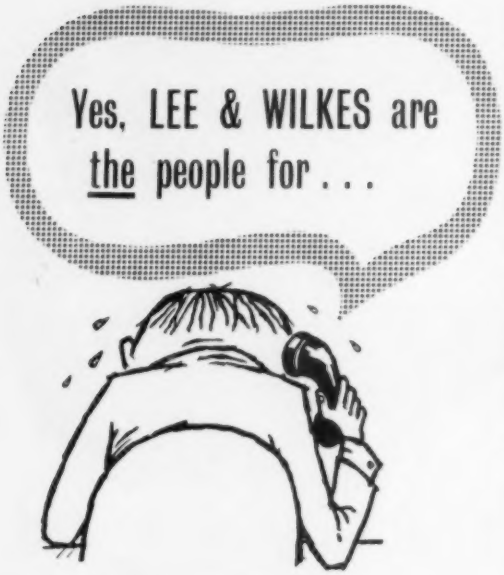

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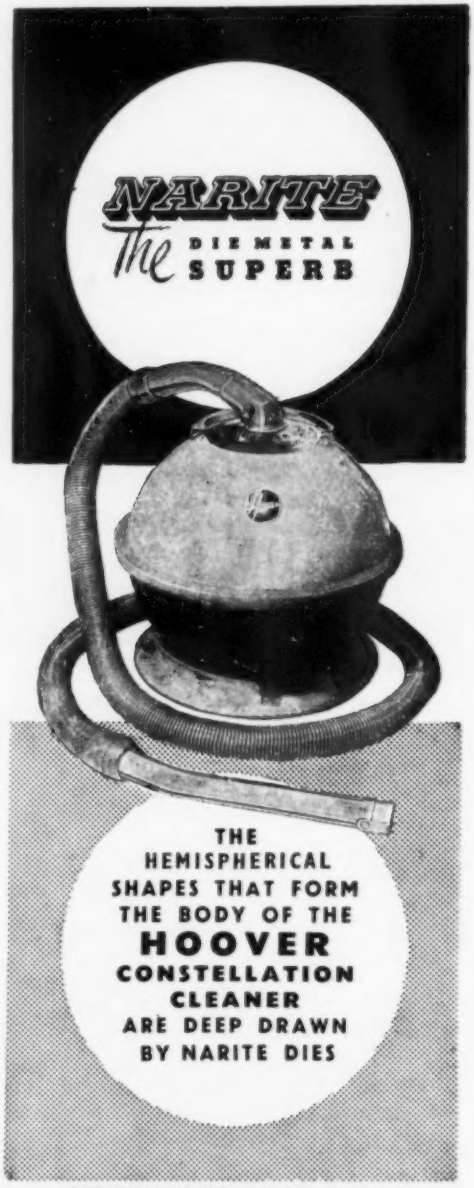
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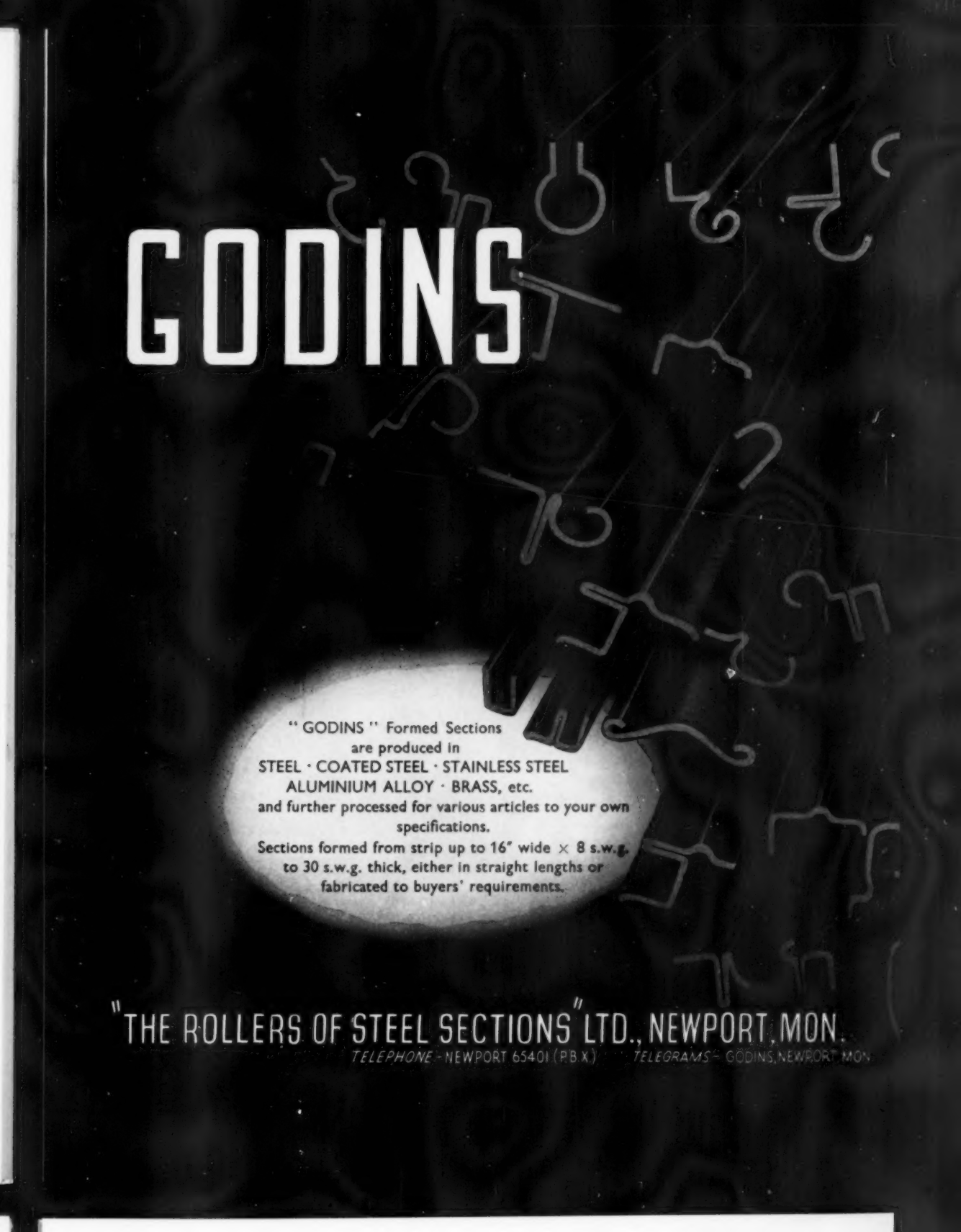

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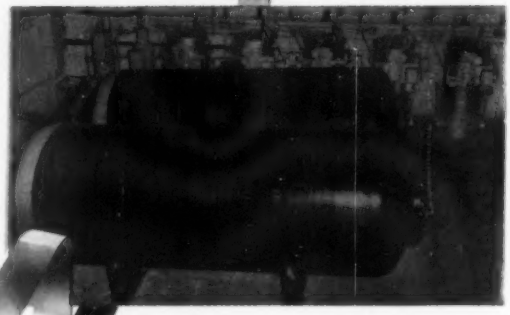

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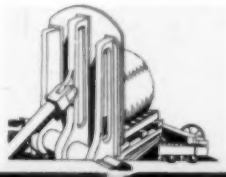

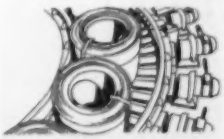

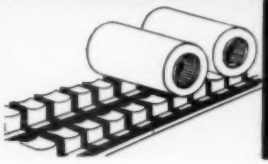

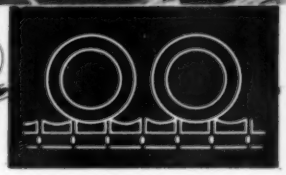

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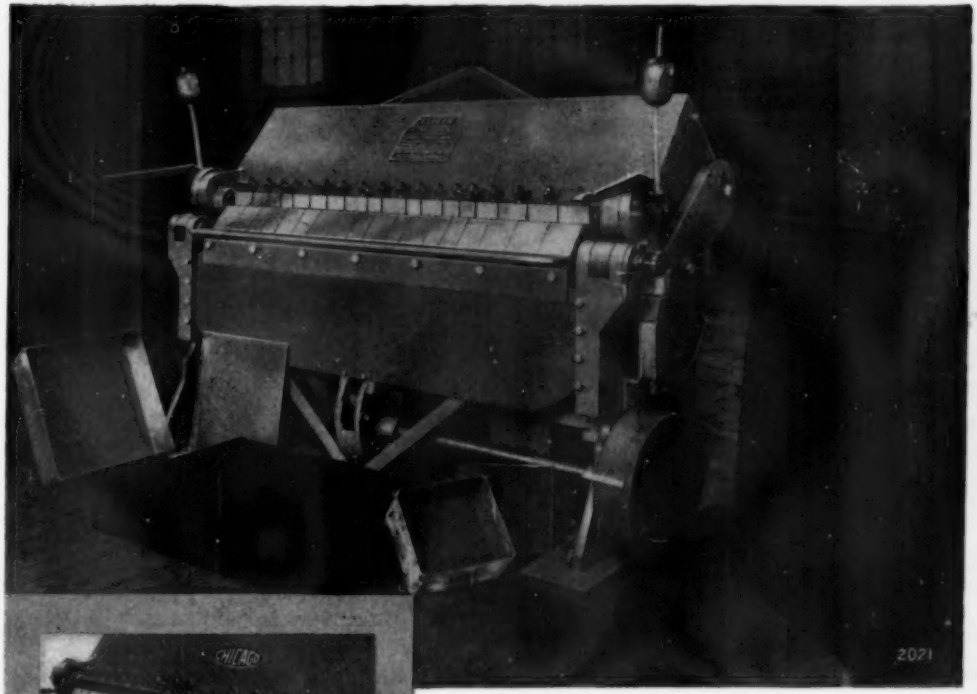

Photograph above shows No. 62 6 ft. Brake with samples of work, by courtesy of Messrs. British Insulated Callender's Cables Ltd., Prescot.

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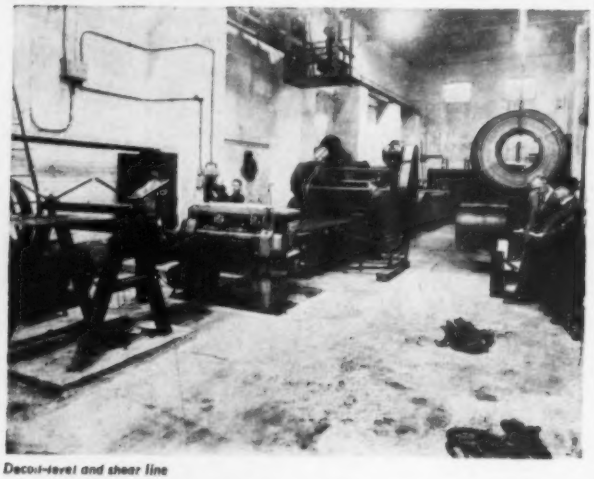

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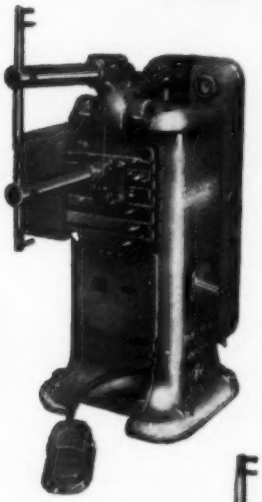

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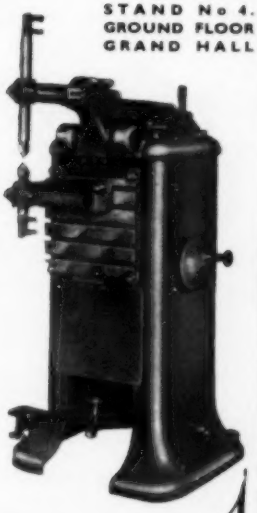

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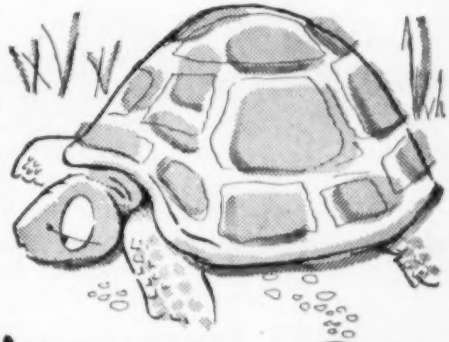

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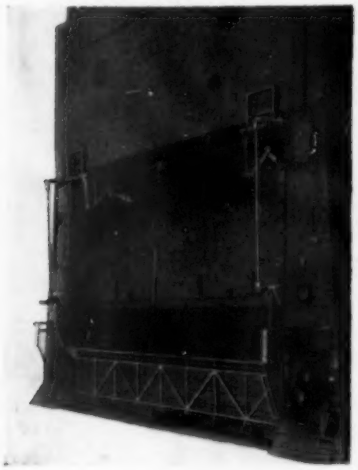

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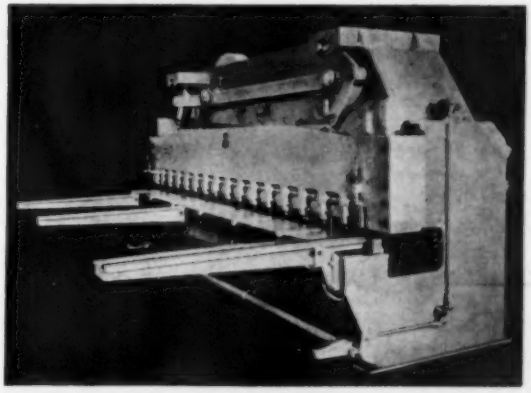

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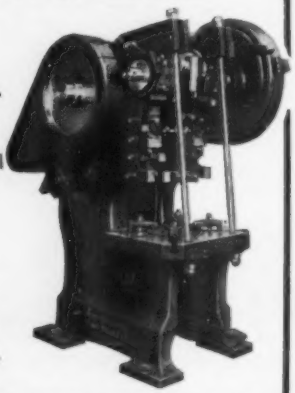

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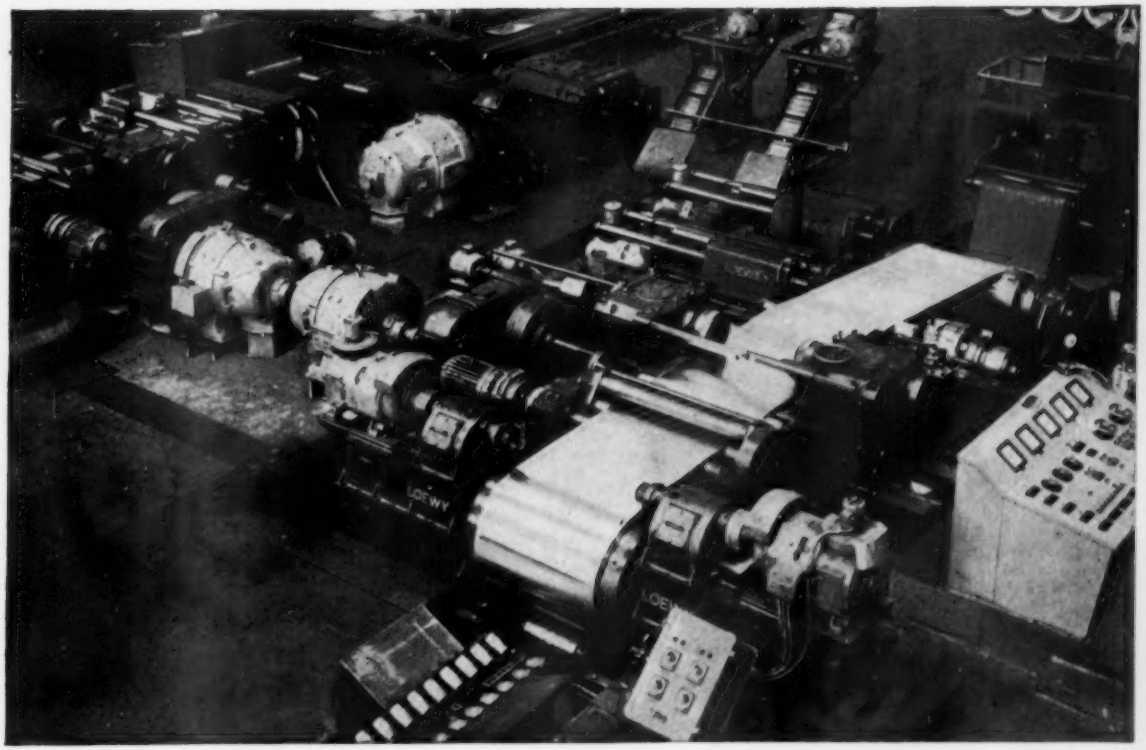

By courtesy of Cie Francaise des Metaux

Edge Trimming and Slitting Line
(foreground)

Edge Trimming, Levelling and Cutting-to-Length Line
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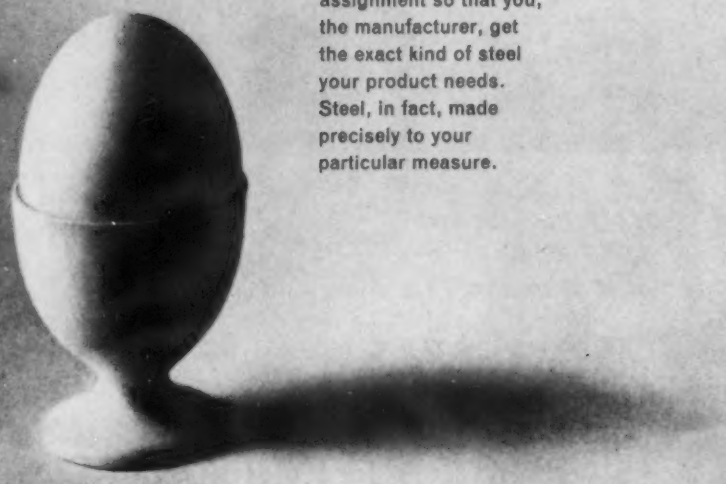

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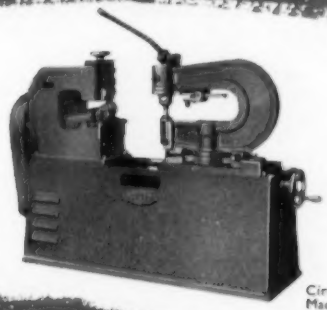

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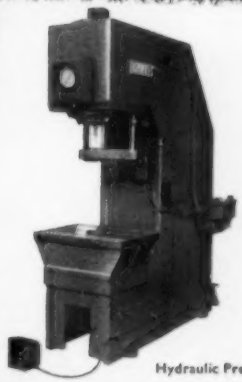

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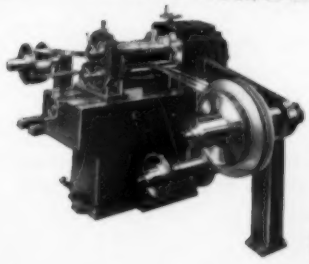
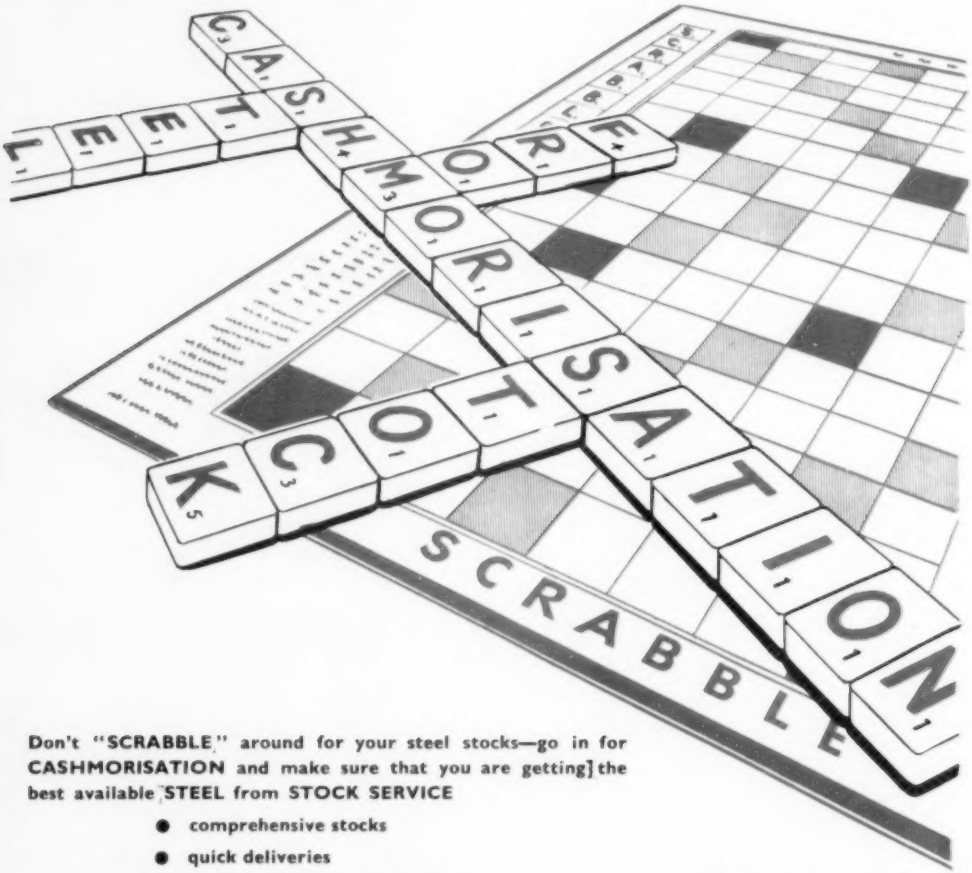


Rotary Gang Slitting Machines



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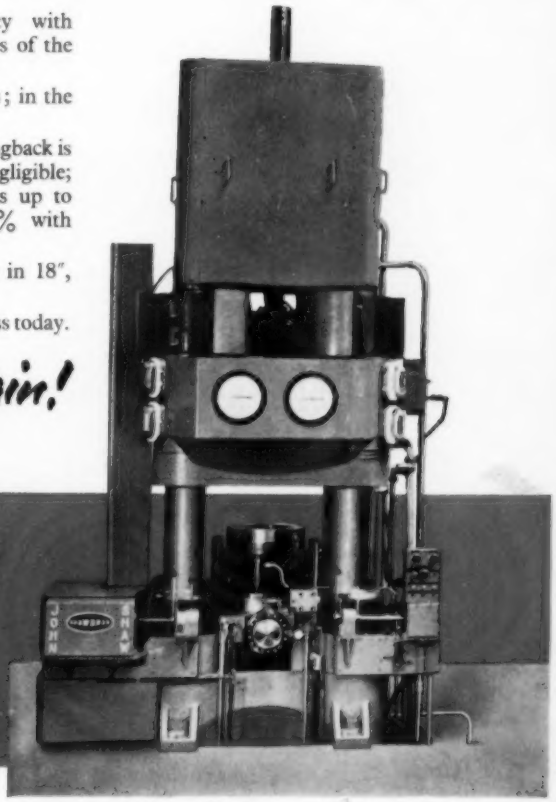

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The operating sequence of the "SHAWDRAW" is as follows :—

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3 Pressure oil is pumped into flexible diaphragm to a predetermined setting.

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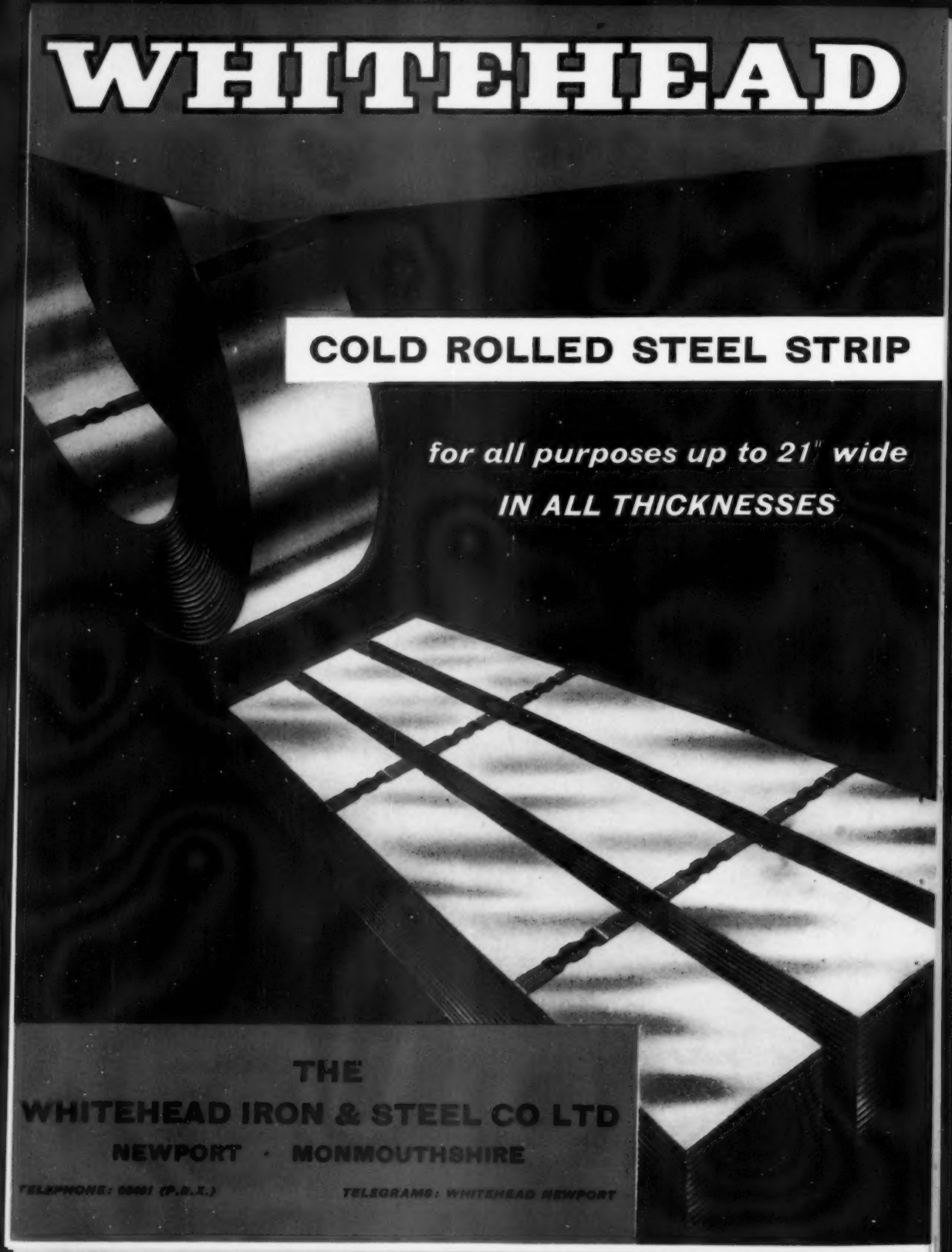

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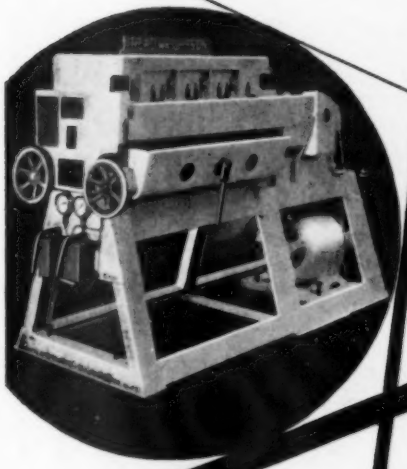
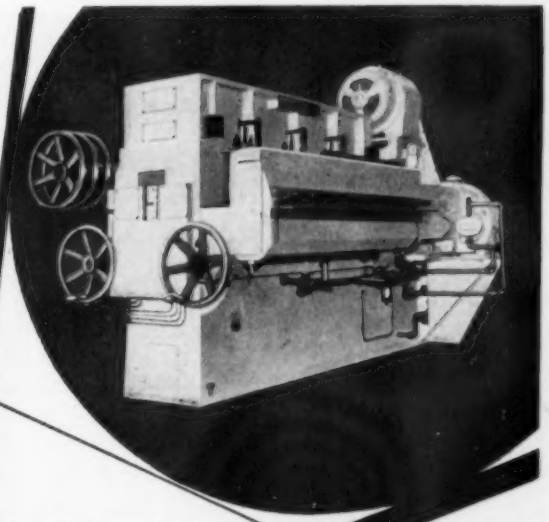
CBC 518

aluminium foil or armour plate

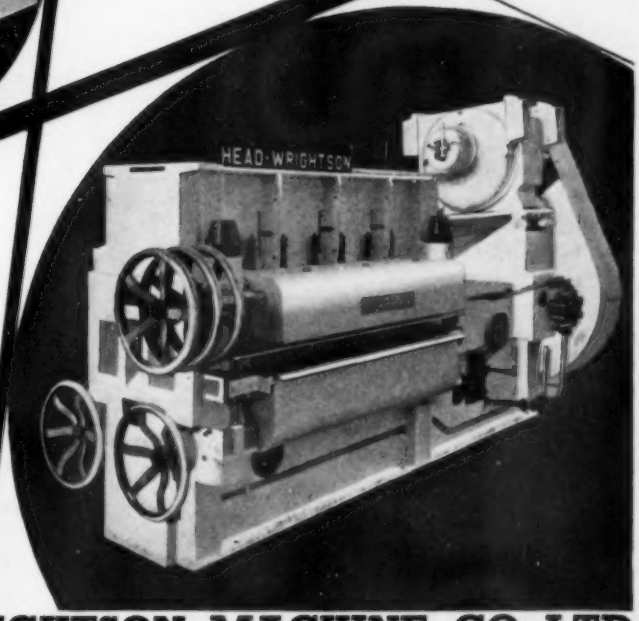
Left: 1½" Pressure Regulating Roller Leveller





Top: 1¾" Processor Leveller

Bottom: 2½" Pressure Regulating Roller Leveller



The Head Wrightson Machine Company manufactures a very wide range of roller levellers for levelling from aluminium foil to heavy steel plates. Further information is available on request and our Sales Engineering Department will be pleased to give advice. For immediate service telephone Middlesbrough 43401.

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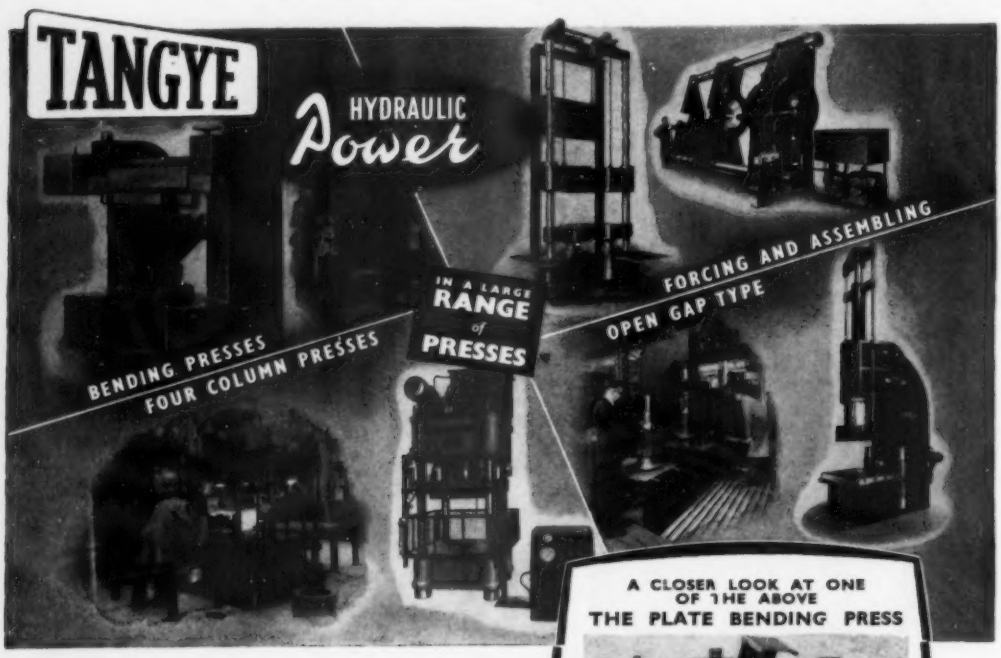
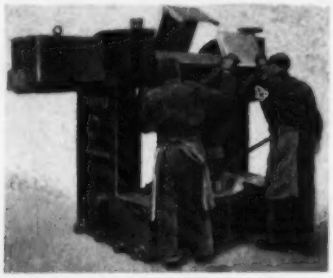


A CLOSER LOOK AT ONE OF THE ABOVE

THE PLATE BENDING PRESS



A feature of this press is its swinging head. The illustration shows a box shape being produced as demonstrated by the diagrams. The ultimate shape of the workpiece requires the swinging head feature to allow for its removal.

The convenience and simplicity of CONTROLLED HYDRAULIC PRESSURE harnessing almost limitless power, lends itself to many applications and proves to be an increasing influence on the pattern of modern engineering design.

The examples we show of presses are only a small selection but enquiries for equipment covering any application of hydraulics receive careful consideration by the Hydraulic Division designers.

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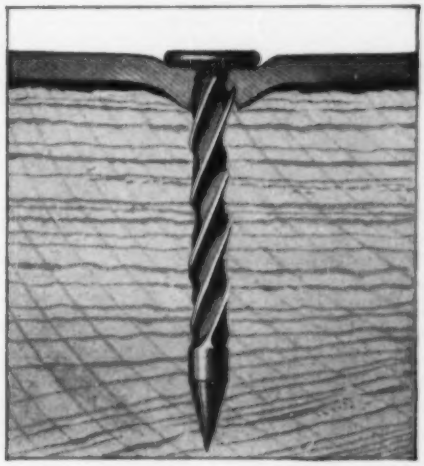

You can see here why Nettlefolds-Parker-Kalon Screwnails make stronger fastenings. The hardened spiral threads cut into the metal and worm into the wood like a screw. Besides holding the metal firmly to the wood, these threads prevent the Screwnail from backing or pulling out. No punch is needed to make the starting hole—the hardened needle point easily pierces light gauge sheet metal, without bending or breaking. Every Screwnail goes in and stays in.

Nettlefolds-Parker-Kalon Screwnails finished as plain steel or cadmium-plated, are supplied in boxes of 1,000 in each size. They are available with countersunk, round, flat and large round heads.

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Hardened Screwnails

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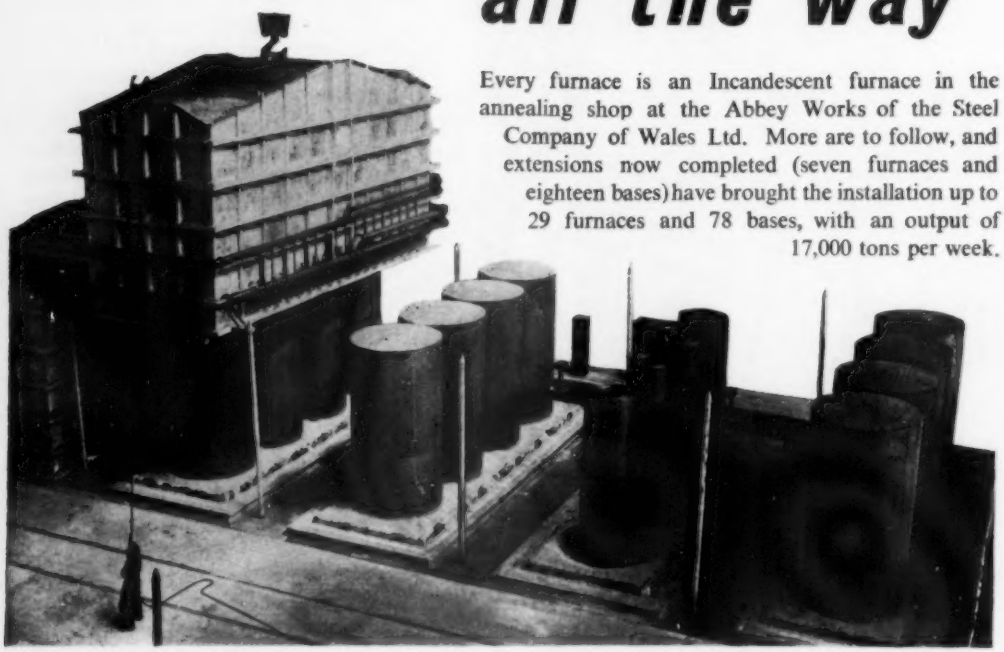
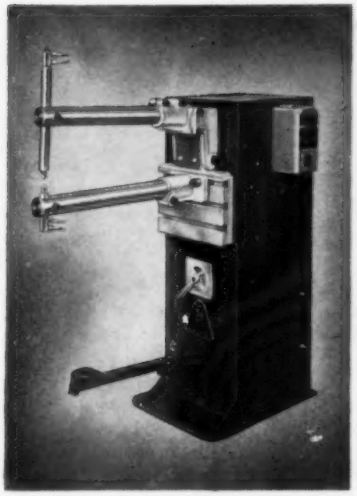
all the way



Every furnace is an Incandescent furnace in the annealing shop at the Abbey Works of the Steel Company of Wales Ltd. More are to follow, and extensions now completed (seven furnaces and eighteen bases) have brought the installation up to 29 furnaces and 78 bases, with an output of 17,000 tons per week.

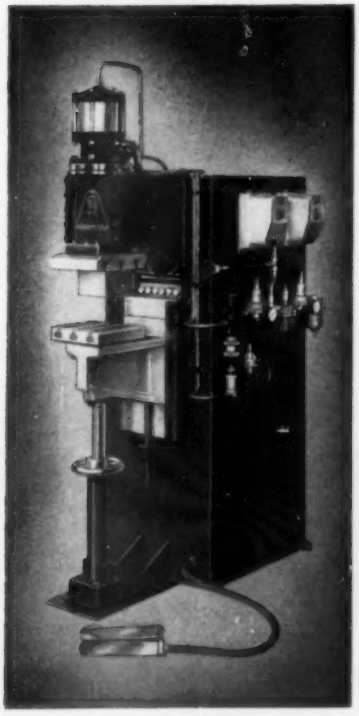
THE INCANDESCENT HEAT CO. LTD • SMETHWICK • ENGLAND

16/10A/60



High Quality
High Efficiency

RESISTANCE WELDERS



for all purposes

Specifically designed to reduce operator fatigue to the absolute minimum, S.R.W. Resistance Welders give a proportionately higher productivity rate with consequent reductions in overheads and operating costs.

They are of extremely robust construction, can be depended upon for complete reliability and all machines are guaranteed for 12 months against defective workmanship and design.

Good delivery and the services of our qualified technical staff are available to advise on your welding problem.

Manufacturers of all types of Welding Machines including: Foot and Air Operated Pivot Type Spot Welders. Vertical Sliding Head Spot and Projection Welders with full electronic control. Seam Welders. Flash Butt Welders. Rivet Heaters. Auto Wire Butt Welders. Vertical Sliding Head Electric Resistance Hot Closing Machines with full electronic control of pressure and current.

Illustrated top left is a 16½K.V.A. - 25 K.V.A. Foot Operated Spot Welder.

Bottom left is shown an 80 K.V.A. combined Spot and Projection Welder. Other capacities available.

STANDARD RESISTANCE WELDERS LIMITED

MAYPOLE FIELDS · CRADLEY · STAFFORDSHIRE

'Phone : CRAdley Heath 69421. 'Grams : Endurance Cradley Heath.

Ductile

STEELS LIMITED
WILLENHALL, STAFFS.
TEL. 601 (P.B.X.)

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CAN **PROPANE**
GIVE YOU GREATER OUTPUT?

For the right answer, for the right gas,
and for the best service—ask British Oxygen Gases

Does your type of production call for Propane? British Oxygen Gases will give you an unbiased answer. Because British Oxygen supply gases for all purposes, they can help you from experience to choose the most efficient, most economical gas for your particular production needs.

Only British Oxygen Gases has this breadth of experience and only British Oxygen Gases can offer you such a complete delivery service of industrial gases . . . in cylinders, or in bulk from their nation-wide tanker fleet—and lend you storage tanks as well if you need them.

BRITISH OXYGEN GASES LIMITED A BOC Company

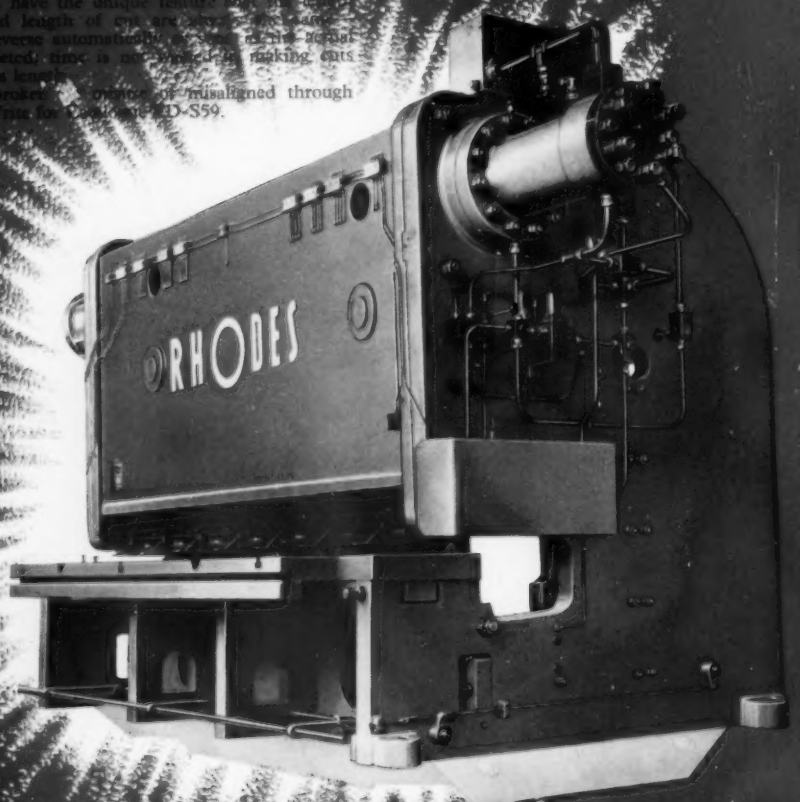
SPENCER HOUSE, 27 ST. JAMES'S PLACE, LONDON S.W.1.

RHODES

FLUID DRIVE SHEARS

PATENTED

This revolutionary design of shears [illegible] mechanical action and electro-hydraulic [illegible] renders other designs obsolete. [illegible] Drive Shears have the unique feature [illegible] of stroke and length of cut are [illegible] the shears reverse automatically [illegible] cut is completed; time is not [illegible] of superfluous length. [illegible] Cannot be broken by [illegible] overloads. Write for [illegible] D-S59.

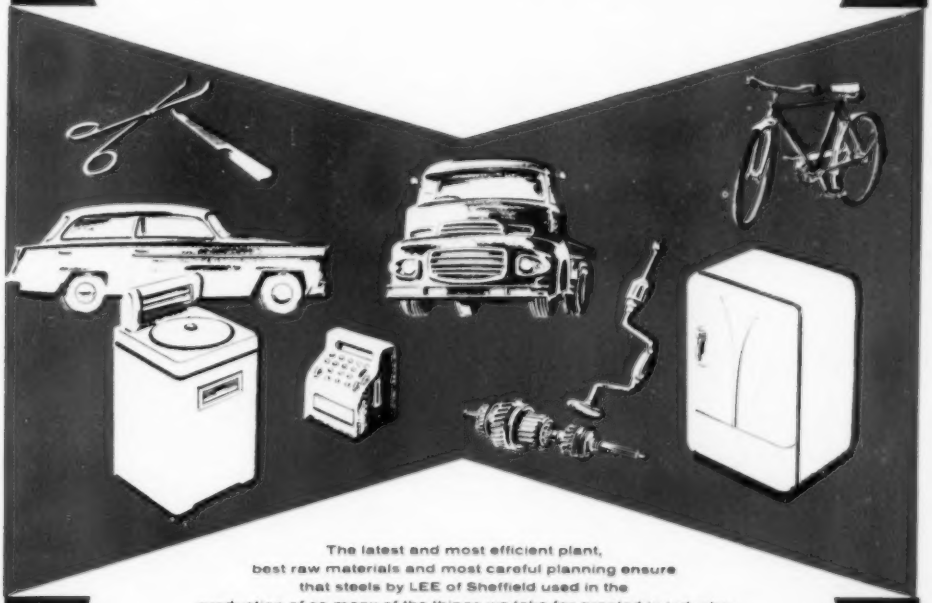


RHODES OF WAKEFIELD

JOSEPH RHODES AND SONS LIMITED

RFSI

Steel by
LEE of SHEFFIELD



The latest and most efficient plant,
best raw materials and most careful planning ensure
that steels by LEE of Sheffield used in the
production of so many of the things we take for granted in industry
and commerce, are of the highest quality.

Cold Rolled Mild and High Steel Strip · Trubrite Stainless Steel Strip
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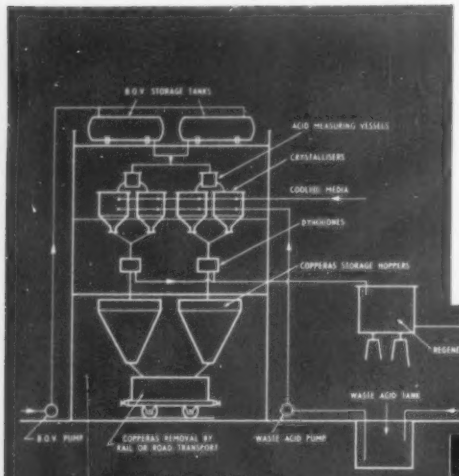


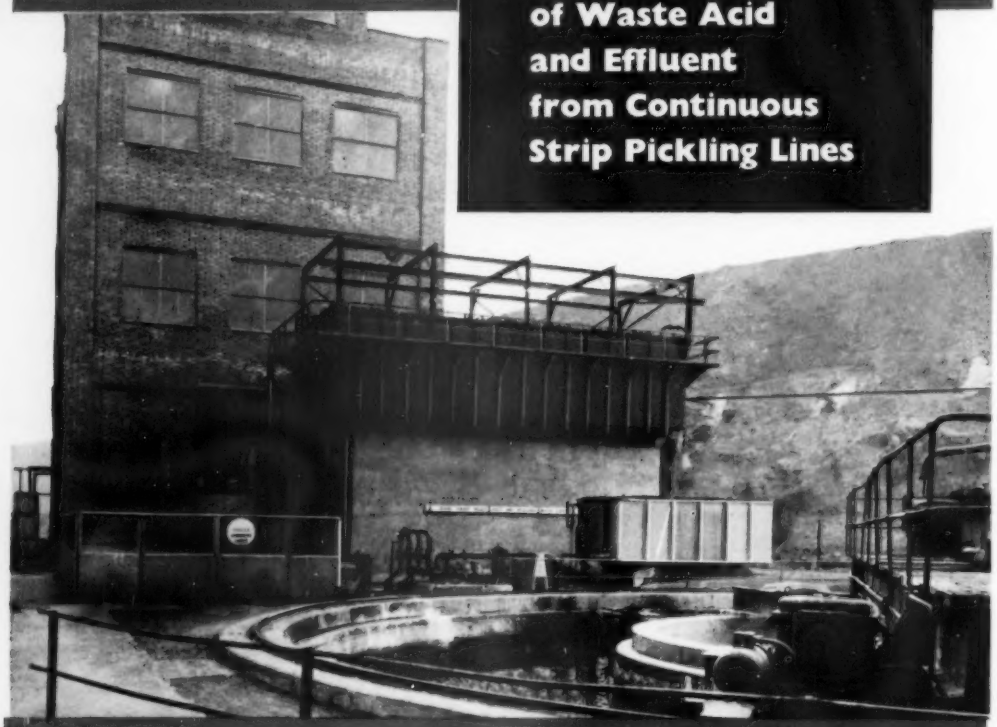
ACID RECOVERY PLANT FLOW DIAGRAM

The sulphuric acid regeneration plant recently installed by John Thompson (Dudley) Ltd., at the new Brinsworth Mill of Steel, Peech & Tozer, is probably the largest of its kind in this country. The complete plant is capable of treating all spent pickle liquors from the continuous strip lines in the mill, and provision has been made for doubling the capacity of this plant at a future date to meet the demand when the mill is working at maximum capacity.

In addition to the above there is installed a large neutralisation plant for dealing with all waste effluents from the continuous strip lines. These plants are larger than any likely to be required in the wire industry, but the same principles are applicable to plants on a smaller scale and of smaller capacity, which would be of considerable interest and value to the medium and large wire mill using sulphuric acid.

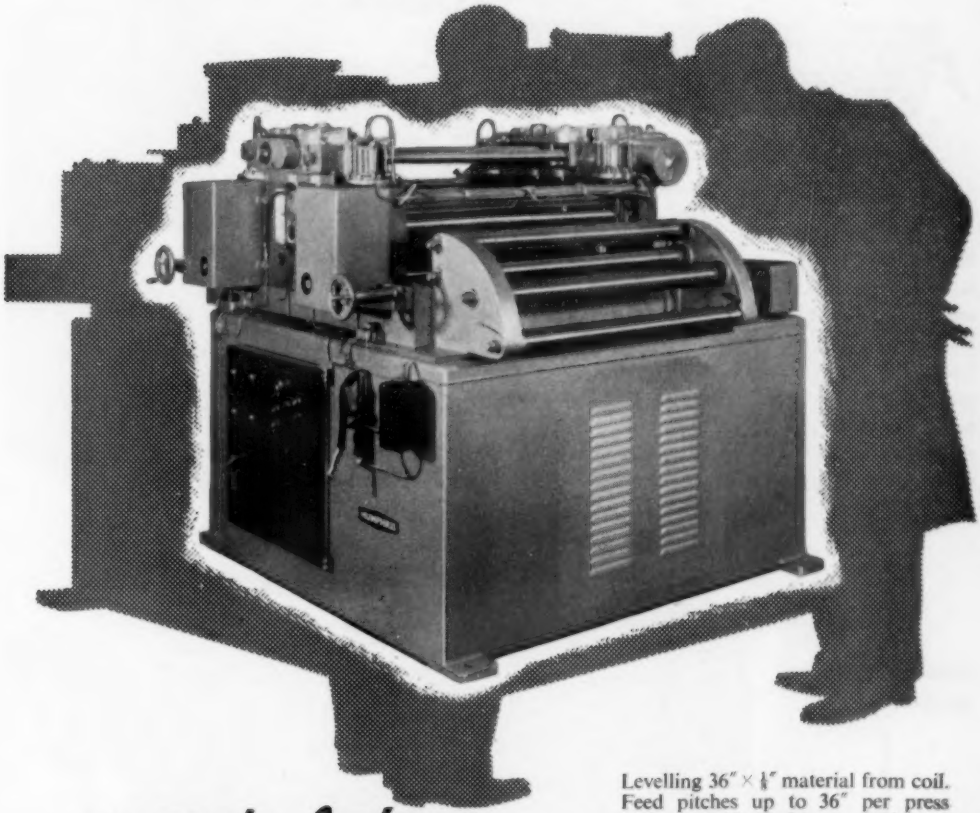
JOHN THOMPSON (DUDLEY) LIMITED
JOHN THOMPSON GROUP

Treatment of Waste Acid and Effluent from Continuous Strip Pickling Lines



JOHN THOMPSON (DUDLEY) LTD DUDLEY WORCS.

following its introduction last month . . . .



we again feature this NEW strip levelling and feeding machine

Levelling 36″ × ¼″ material from coil. Feed pitches up to 36″ per press cycle, at 40 strokes per minute ! This is the performance of Model RPL. 36-36 Feeding and Levelling Machine.

Available with all coil handling equipment.

A typical *complete* line will be featured in our next advertisement.

pressmaster — *the spearhead of development in the pressed metal industry*

HUMPHRIS & SONS LTD · POOLE · DORSET

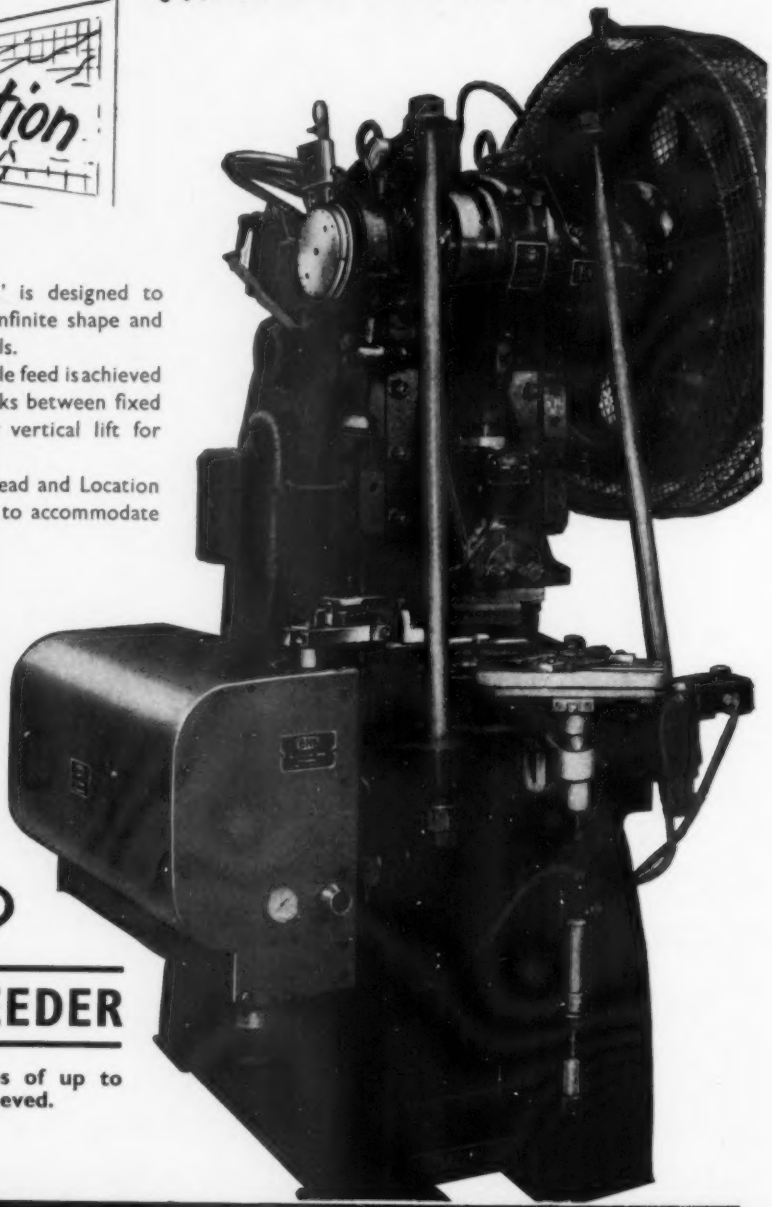
TELEPHONE : POOLE 1800 TELEGRAMS : HUMPSONS

HUMPHRIS

We have a HAND in increased Production

The B.H.P. "Hand" is designed to feed components of infinite shape and variety into press tools.
An accurate and reliable feed is achieved because the Arm works between fixed stops and has a truly vertical lift for pickup and placing.
A simple change of Head and Location is all that is required to accommodate different shapes.

Double your output!



BHP

PRESS FEEDER

Production increases of up to 400% have been achieved.

Fully Patented.

B.H.P. MACHINE TOOL CO LTD · 91 WATTVILLE ROAD · BIRMINGHAM 21

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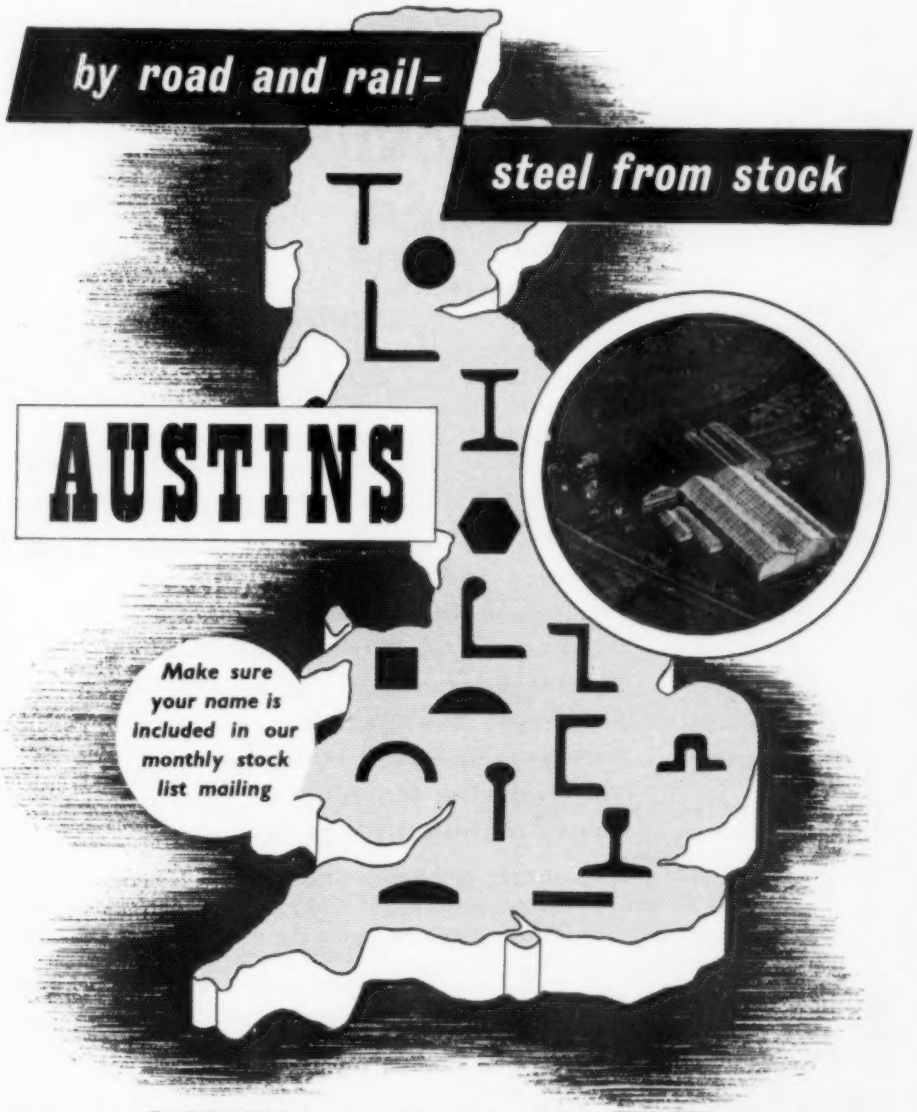

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Make sure you visit the greatest engineering event of the year—The International Machine Tool Exhibition . . . No-one concerned with quantity production—whether in technical, administrative or operative capacity—can afford to miss this vast and truly comprehensive show at Olympia, London. It summarizes the best of contemporary production techniques; it shows the shape of things to come!

Machine Tools
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Woodworking Machinery
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Here's your opportunity to see them all under a single roof—to see many of them powered and in operation—to discuss their application to your own production problems with the world's best-informed production experts.

International Machine Tool Exhibition 1960

Organized by
The Machine Tool
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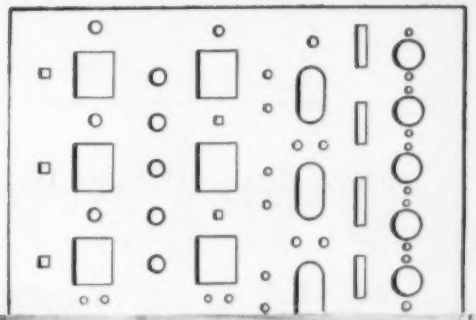
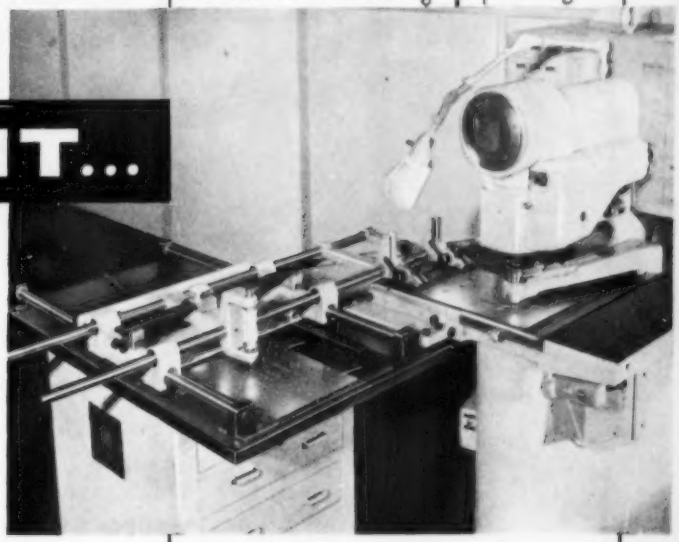
PUNCHING
NOTCHING
NIBBLING



WALES

STRIPPIT...

sheet metal
FABRICATOR
and
POSITIVE
DUPLICATOR



Ideal for short or pilot runs — model shop and experimental work. The patented punch, stripper and die button assemblies can be changed from one size or shape to another in less than 20 secs.

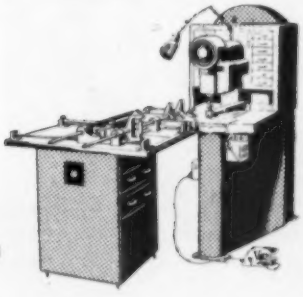
The POSITIVE DUPLICATOR converts the FABRICATOR to a medium run production machine for precision sheet metal work or for cold-punching printed circuit boards without heating, die-making, drilling or deburring.

Write for illustrated literature on full STRIPPIT range of accessories and tooling.

SPECIFICATION

STROKE — ⅜"
SHUT HEIGHT — 5½" stroke down (non-adjustable)
MOTOR — 1 h.p. 220/440v 3 phase 50 cycle
STROKES PER MINUTE — 165 for single punching or nibbling
THROAT DEPTH OF PRESS — 15"
TABLE WORKING SURFACE — 30" wide x 20" deep

INTERNATIONAL MACHINE TOOL EXHIBITION 1960
Olympia - London
June 25 - July 8
STAND NOS. 22 & 321
GRAND HALL.



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Telephone: HOVE 37253 *Telegrams: Garantools, Portslade*

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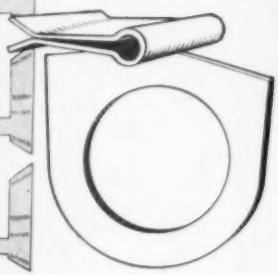
FIRTH BROWN

CCW

PUNCHING TOOL-STEEL



CCW provides a notable combination of hardness and toughness making it an excellent shock-resisting tool steel for cold punching work. Amongst its many uses are press and forming tools, tin-can dies and rings, casement tools for mild steel and cold heading dies.

A useful degree of red hardness at elevated temperatures has led to CCW being used also for hot heading dies, forming and piercing tools and purposes where short contact with hot metal involves only restricted rise in tool temperature. Very clear printed data on this steel is available upon request.

Heavy punches
Press and forming tools
Tin-can dies and rings
Casement tools for mild steel
Caulking and bending tools
Cold heading dies
Hot heading
Forming and piercing tools

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ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

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ALL GAUGES

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LARGE STORAGE CAPACITY AVAILABLE

Please Contact

BENGEWORTH STEELS LTD.

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Telephone: RODney 7571 (2 lines)

Our Managing Director believes that this print, showing a team of four little horses, is the earliest advertisement for Desoutter Multiple Power Tools. But then, he believes anything. He believes that the chariot race from Ben-Hur is a 13-minute commercial for the same thing!
Mind you, he says, the jingle* didn't come across very well.

* A group of Desoutter pneumatic screwdriver/nutrunners, mounted on a stand and controlled by a single lever, will drive home several screws or nuts in one go!

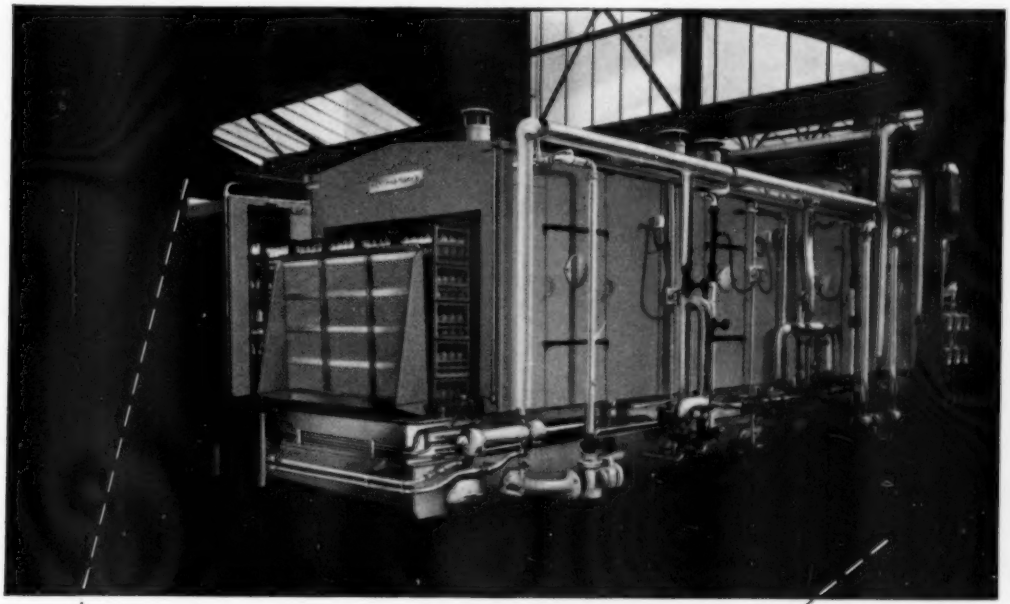
DESOVTTER

Multiple Power Tools

Desoutter Bros. Ltd, The Hyde, Hendon, London, NW9. Colindale 6346

CRC 325

Stelvetite-plastic bonded to steel-has put a new face on the Graham-Enock Dairy Steriliser



SOMETHING NEW IN STEEL Until recently steel always needed periodic repainting. But not any more. Stelvetite even arrives with a finished surface in the colour you choose.

A surface finish which lasts for ever. Stelvetite's permanent P.V.C. surface resists scratches, acids, detergents and time. Thus, in all manner of steel fabrication Stelvetite saves on expensive surfacing processes.

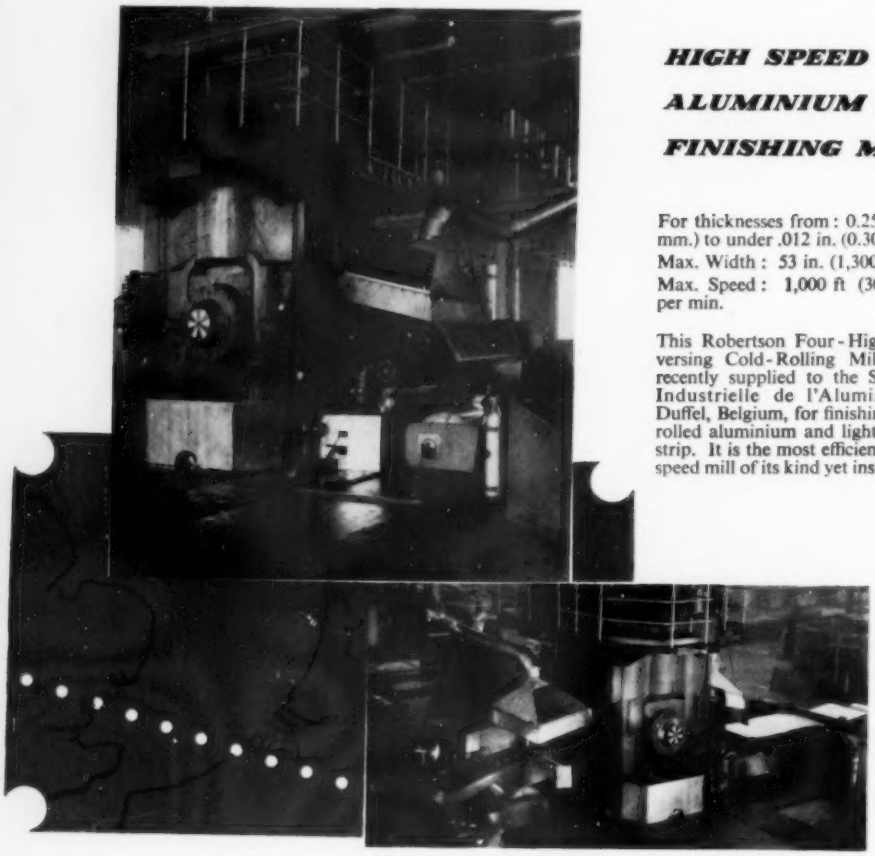
It can be worked and welded as steel, comes in a wide range of plain or embossed surfaces and is used to fabricate, among other things, lifts, doors, car panels, partitioning, furniture, kitchen equipment, walls and cladding—all of them colourful and permanent. Investigate Stelvetite. It may well save you a small fortune, or a large one.

All enquiries about Graham-Enock Dairy Sterilisers should be made to Graham-Enock Manufacturing Co. Ltd., Stamford Hill, London, N.16.

Stelvetite

Plastic bonded to Steel

STELVETITE—made by John Summers and Sons Ltd. who produce over 52,000 miles of sheet steel every year. Write to us at Shotton, Chester, for full information.



HIGH SPEED ALUMINIUM STRIP FINISHING MILL

For thicknesses from : 0.25 in. (6 mm.) to under .012 in. (0.30 mm.)
Max. Width : 53 in. (1,300 mm.)
Max. Speed : 1,000 ft (300 m.) per min.

This Robertson Four-High Reversing Cold-Rolling Mill was recently supplied to the Société Industrielle de l'Aluminium, Duffel, Belgium, for finishing hot rolled aluminium and light alloy strip. It is the most efficient high speed mill of its kind yet installed.

THE ROLL STAND. Roll housings and bearings are of massive construction. Support rolls float in Robertson film lubrication bearings which remain cool at sustained maximum loads and speeds. Back tension on the strip during the initial run is applied by a multi-roll bridle. This unit is hydraulically controlled and of a new and improved design.
Roll temperature is controlled by valves which regulate the quantity and distribution of the rolling oil.
Wiper rolls prevent rolling oil from passing on to the coiled strip.
Strip thickness is continuously checked by flying mikes.
1,000 h.p. main mill motor drives the rolls through totally enclosed, double helical, jet-lubricated pinion drive. It delivers constant torque up to half speed, and thereafter constant horse power up to full speed.

W. H. A. ROBERTSON & CO. LTD

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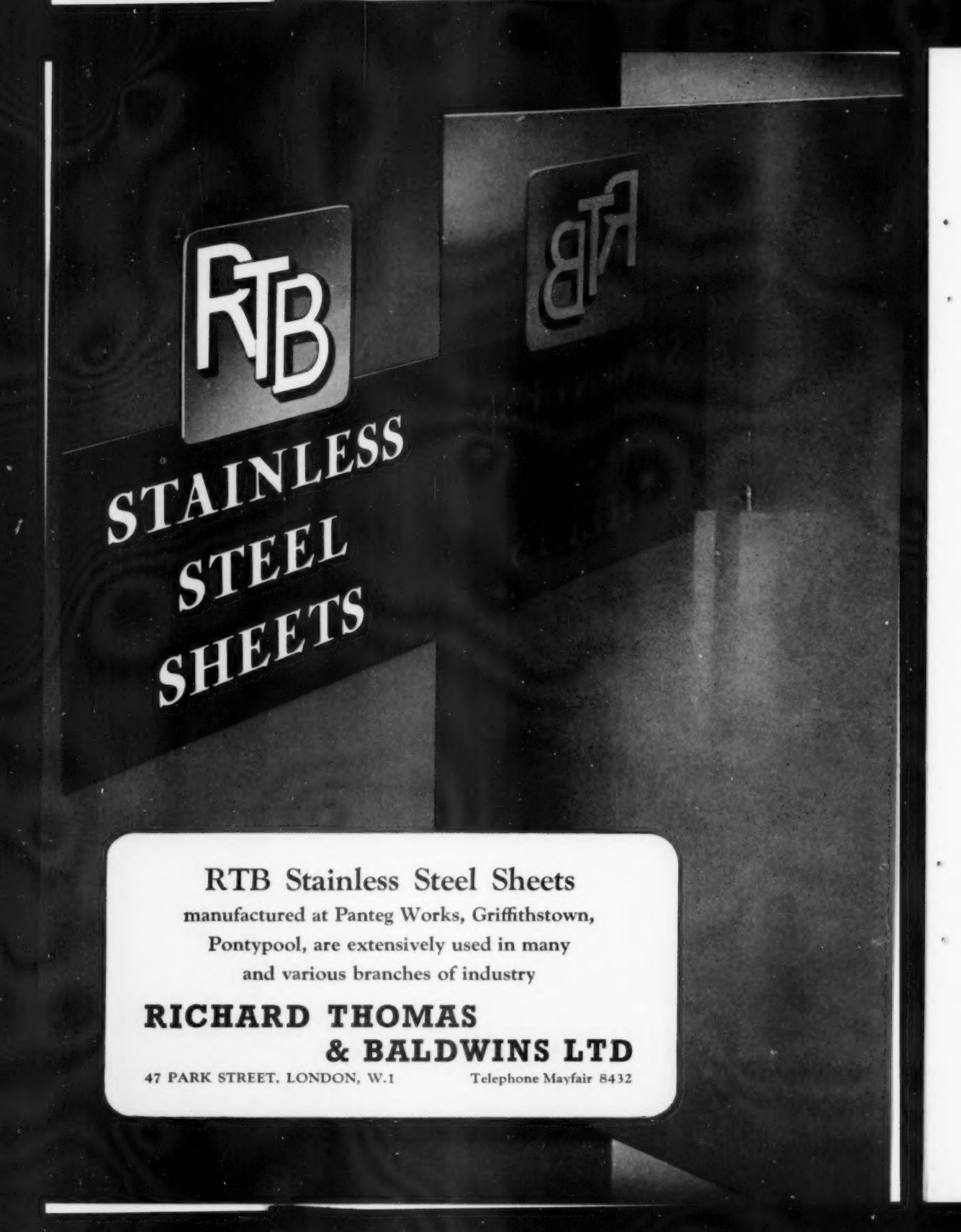
ON TIME AGAIN!
"The First batch of a major contract for HME Double Sided Presses, leaving our Works for installation at Roneo Ltd., Norwich"
HME



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manufactured at Panteg Works, Griffithstown, Pontypool, are extensively used in many and various branches of industry

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APRIL 1960
No. 396 Vol. 37

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Incorporating PRESS TOOL ENGINEERING

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Working Metals by Detonating Explosives 253
J. H. Cook
When a detonating explosive is fired directly on a metal plate it will either deform it locally or disrupt it; therefore, in shaping a metal plate, it is desirable for control purposes that the explosive should be some distance remote from its target. If the explosive charge is fired in water and it is arranged that the water is in contact with the metal to be shaped, then by suitable arrangements of the explosive charge a uniform pressure can be brought to bear on the metal to be worked. This paper was presented at the annual conference of I.S.M.E.

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On the face of punches and dies and on the side of punches or the internal ring of dies, wear takes place by slipping of sheet material under pressure. Shearing thin sheet metal the wear on the face of tools is much larger than the wear on their surfaces. As a result of the wear on the face of tools the punches and dies become conical near their edges, but they still remain relatively sharp. This change of the tool-profile results in only a slight increase of the shearing-load, but a heavy increase of flash. It is possible to assess the wear of tools by simply measuring the flash. This paper was presented at the annual conference of I.S.M.E.

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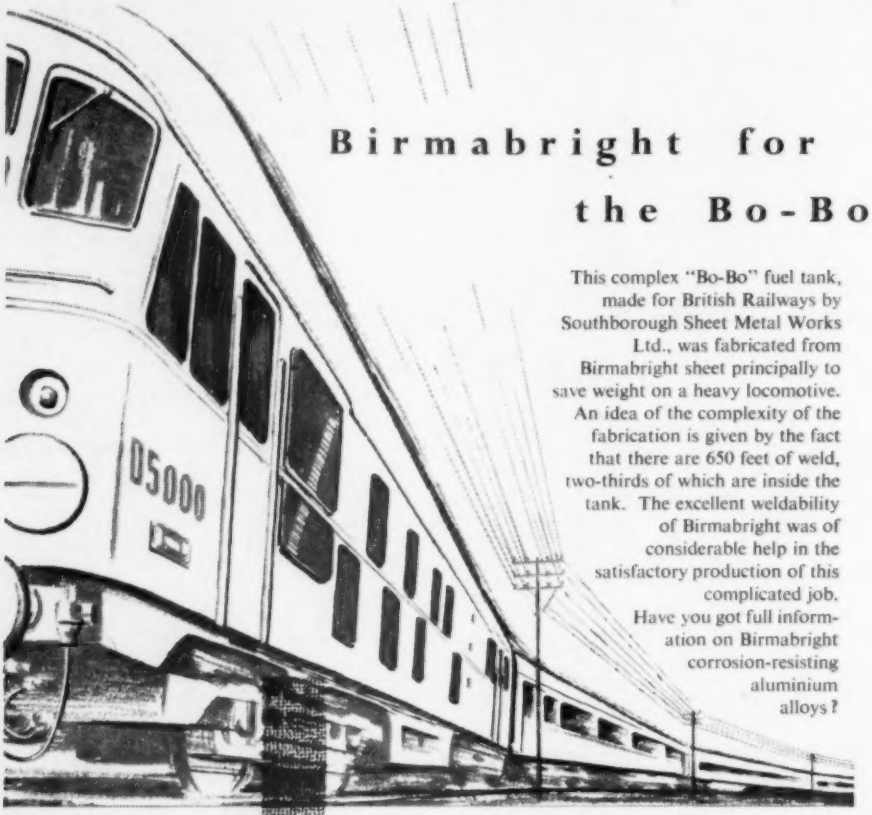
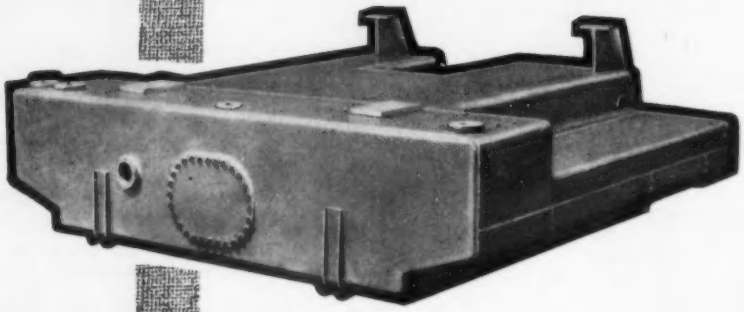


Birmabright for the Bo-Bo

This complex "Bo-Bo" fuel tank, made for British Railways by Southborough Sheet Metal Works Ltd., was fabricated from Birmabright sheet principally to save weight on a heavy locomotive. An idea of the complexity of the fabrication is given by the fact that there are 650 feet of weld, two-thirds of which are inside the tank. The excellent weldability of Birmabright was of considerable help in the satisfactory production of this complicated job. Have you got full information on Birmabright corrosion-resisting aluminium alloys?



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Incorporating PRESS TOOL ENGINEERING

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WHEN IS A TON . . . ?

IN one of the immortal golfing stories related by P. G. Wodehouse in his book "The Clicking of Cuthbert", occurs the dramatic incident of the young lady who is trying to conceal from her affianced the horrid truth that her game is hockey and that she knows nothing of the hallowed ritual of golf. When caddying for him one day her advice is sought as to how to extricate the ball from a particularly bad lie and she suggests that it be given "a good hard knock". This her intending spouse immediately interprets with the perspicuity of a plus-two man as advocating the use of a heavy iron; he follows her advice and holes out in two under par.

Much the same sort of blend of ignorance and intuition born of experience was used for many years in determining the force necessary to carry out a given metal pressing or drawing operation, and the variation in this force with the progress of the operation. Even today no clearly-defined or generally-accepted criteria exist for the rating of power presses, and the introduction of double and triple actions has complicated the picture still further.

As is well known, the maximum force exerted by a mechanical press is when the crank is within a very few degrees of bottom dead-centre and this force falls off very rapidly towards mid-stroke. The system which is generally used in such operations as the forming of car-body pressings is to rate a press on the tonnage it will exert through the last half inch of punch travel at the bottom of the stroke. In addition to the actual drawing force exerted by the press ram it is also necessary in most deep-drawing operations to supply varying amounts of blankholder pressure applied through the medium of either a cushion on a single-action press or the outer slide on a double-action press. In the case of the double-action press the blankholder load must be supplied by the crankshaft, but as it is not used as part of the forming force, it is not generally added to the quoted rating of the press.

Measurements made of the drawing load from the time that the punch contacts the blank until it has travelled to bottom dead-centre of the crankshaft have shown that the peak loading occurs very shortly after the punch has entered the die, and that the load falls off quite significantly during the progress of the draw except in those cases where a severe bottoming or coining operation is involved. Therefore, when determining how powerful a press must be to carry out a given drawing operation, consideration must be given to the position of the crankshaft when the punch contacts the workpiece, as at mid-stroke the pressure available is only about thirty per cent of that available for drawing at bottom dead-centre. In most cases therefore it is necessary to use a press capable of exerting at the bottom of its stroke a tonnage which may be up to sixty per cent greater than would be theoretically necessary to produce a given deep draw. Furthermore, additional power must be available for supplying the necessary blankholder pressure.

While these points are appreciated by many of those closely associated with press work, there is evidence that misunderstandings of the exact significance of the rated tonnage of a power press still occur. An attempt to produce a generally acceptable code of practice in this matter would be very worthwhile.

INSTITUTE OF SHEET METAL ENGINEERING

Recent and Forthcoming Activities

ANNUAL GENERAL MEETING

THE 15th Annual General Meeting of the Institute will be held at the Cafe Royal, Regent Street, London, W.1, at 12 noon on Wednesday, May 4, 1960, and will be followed by an Institute Luncheon. The agenda for the meeting and application form for tickets for the Luncheon will be circulated to all members in the near future.

INTERNATIONAL DEEP-DRAWING RESEARCH GROUP MEETING IN PARIS

Reference in general terms has been made previously on this page to the Colloquium on " Sheet Metal Forming, with Special Emphasis on Methods of Testing " organized jointly by the International Deep-Drawing Research Group and the Société Française de Métallurgie, to be held in Paris from May 23-27, 1960, inclusive. The definitive programme of this meeting has now been issued and circulated to all members of the British Deep-Drawing Research Group of the Institute of Sheet Metal Engineering, and this programme is detailed in full in page 297 of this issue. It is regretted that owing to the short time available before the date of this meeting, it will not be possible to make hotel and travel arrangements on behalf of individuals attending the meeting, but it is hoped that it will be possible to circulate prior to the meeting a list of all members participating.

This is the first full-scale meeting sponsored by the International Group and it should command wide support from all member countries.

WORKS TOUR IN SOUTH WALES

The biennial tour of works' visits which has been a regular feature of the Institute programme since 1948 will this year be staged in South Wales. The directors of eleven companies have extended invitations to the Institute to include their works in the tour, which will include some of the most outstanding factories in the U.K.

This tour is planned to take place during the first week in October and full details will be circulated to members later this year.

EXPLOSIVE FORMING DISCUSSED AT BRANCH MEETING

Mr. J. H. Cook, who contributed a paper on "Explosive Forming" to last year's annual conference, spoke on the same subject to the Midland Branch of the Institute on February 10.

The keynote of Mr. Cook's lecture was that explosives can be employed to construct rather than destroy. He began by giving a brief outline of the early uses of explosives and then went on to explain the technicalities involved. He then outlined some of the ways in which metal could be worked as given in his paper (published in this issue).

The lecturer made it quite clear that he was purely interested in the research side of his experiments and that he was not prepared to be involved in questions of commercial value. He did point out, however, that any progress in this field will depend on the potential users.

When it came to question time it was quite clear that many people were fascinated by the subject of Mr. Cook's lecture, but at the same time rather incredulous.

Mr. Elkington suggested that there must be considerable wastage, in that the explosion would take place in all directions and not only in the one required. Mr. Cook, however, was quite emphatic that this was not so, and that it is possible to arrange that the pressure-pulse should go in one direction only. Any other pressures are just supporting and of little consequence.

In reply to Mr. Gibbs' query as to cost, the lecturer said that he thought that the cost of explosives would be a matter of shillings. Mould costs, however, he pointed out, could be quite considerable. This prompted Mr. Salmon to ask a question about moulds and the lecturer replied that plaster of paris moulds for one-off jobs would be suitable for any shape required. He pointed out, however, that much greater accuracy could be obtained from a steel die as opposed to a plaster of paris one.

In reply to Mr. Ebsworth's query as to distortion of the metal, Mr. Cook said that the effect of the explosion is instantaneous.

Mr. Burton wanted to know how much hardening of the metal took place and also the amount of spring back. The answer was that using the pulse-water technique there would be no hardening and that if all the air was evacuated from the mould probably no spring back would take place.

The lecturer agreed that thinning of the metal could occur and that this was a problem that had to be tackled.

The lecturer called upon a colleague in the audience to give a brief summary of the safety requirements. It seems that a police certificate is necessary in order to keep explosives, but that this would be easily obtained for reasonably small quantities. It was, of course, advisable that an explosives engineer should be employed if experiments were to be carried out.

The meeting finished with a vote of thanks from Mr. Pullin, who said that it was a great pleasure to listen to a man dedicated to his work, and that he was quite sure that many members would no doubt try and think of suitable applications of Mr. Cook's ideas and judging from the gleam in the eyes of some members of the audience, it may be that the future will produce some experiments in Birmingham that may put the French atomic tests in the shade!

The DEEP DRAWING of COMMERCIALLY PURE TITANIUM

By M.A.H. HOWES, M.Sc., A.C.T.(Birm.), A.I.M.*

SUMMARY

The deep-drawing characteristics of six samples of commercially-pure titanium have been examined each with four surface conditions and three lubricants using the Lucas Swift press.

It has been found that the impurities in the commercially pure grades of titanium have a pronounced effect on the drawability. One surface treatment and one lubricant were found to give particularly good results which have been confirmed in the press shop.

Introduction

THE deep drawing of titanium presents a difficult problem because of the ease with which titanium surfaces " pick up " and gall. Once this process starts the small pieces torn out of the surface act as an abrasive and intensify the galling effect (Fig. 1.) The drawing load is increased by the roughened surface and early failure during drawing is caused. Good surface lubrication is required to overcome this problem.

In this investigation a Swift press has been used to compare the effects of three lubricants and four surface conditions on six batches of commercially pure titanium.

The development of the Swift cup-forming test has been discussed by Kemmis[1], Willis[2] and Swift[3]. In this test the drawability of a material is assessed from the largest blank that can be drawn without failure. For the present investigation the Lucas press, which has been adapted to give controlled direct hydraulic loading of the pressure plate, has been used. The main ram of the press is

* Joseph Lucas Ltd.

Fig. 1 (*left*).—*Galling effect caused by working an unlubricated titanium surface*

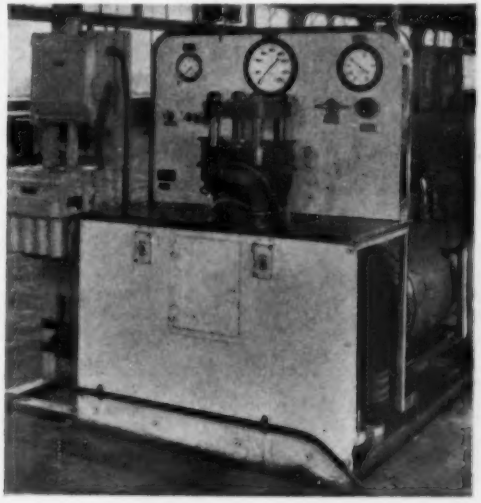


Fig. 2 (*below*).—*General view of Swift press* (*front*)

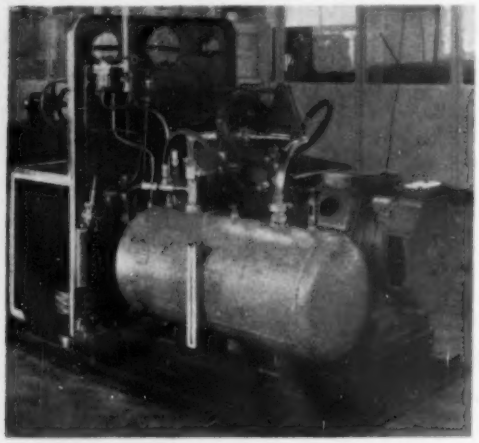


Fig. 3 (left).—General view of Swift press (back covers removed)

hydraulically driven by a Lucas gas turbine pump coupled to a 50-horse-power motor. General views of the press are shown in Figs. 2 and 3.

EXPERIMENTAL WORK

Material

Six different batches of commercially-pure titanium were used in the deep-drawing tests. Four were of American origin supplied to specification Ti75A and two were British material to specification I.C.I.130 and Hylite 10. The composition of the six materials is given in Table I.

Surface Treatment

Four different surface conditions were used for the tests:—

(*a*) Untreated.

(*b*) Oxidized. Blanks in the untreated conditions were heated to 630° C. in air for 15 minutes to thicken the oxide coating. This treatment did not affect the hardness and it has been assumed that it did not affect the other physical properties.

TABLE I—*Composition of the commercially pure titanium materials*

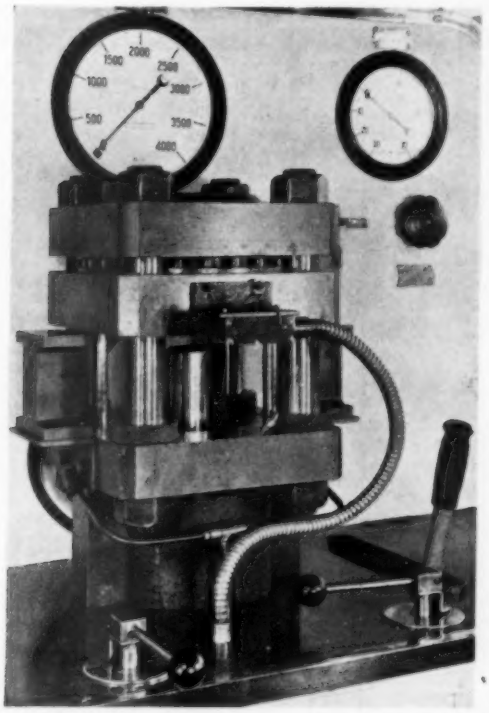
Specimen letter	Specification	Sheet thickness (in.)	Element (per cent)				
			C	Fe	N_2	O_2	H_2
A	Ti75A	0.028	0.09	0.11	0.026	0.150	0.029
B	Ti75A	0.035	0.09	0.02	0.019	0.113	0.043
C	Ti75A	0.050	0.10	0.10	0.026	0.160	0.024
D	Ti75A	0.062	0.10	0.08	0.025	0.224	0.015
E	ICI 130	0.048	0.05	0.10	0.030	0.010	0.009
F	Hylite 10	0.036	0.03	0.07	—	0.100	0.004

In general the main difference lies in the oxygen and hydrogen contents.
The physical properties are given in Table II.

TABLE II—*Physical properties of the commercially pure titanium materials*

Property	A	B	C	D	E	F
Hardness (HV 2½) on centre of section	235	223	235	250	164	178
Average grain-size (mm.)	0.040	0.035	0.037	0.060	0.035	0.030
Erichsen (mm.)	7.38	7.65	6.25	4.74	9.93	9.74
Properties at 0 deg. to rolling direction						
Ultimate tensile stress (tons per sq. in.)	—	45.3	43.2	—	27.8	30.2
0.1 per cent Proof stress (tons per sq. in.)	—	39.2	37.7	—	22.2	21.8
Elongation (per cent on 2 in. gauge length) ..	—	23	24	—	29	21
Properties at 45 deg. to rolling direction						
Ultimate tensile stress (tons per sq. in.)	40.8	44.4	41.4	43.2	28.6	30.8
0.1 per cent Proof stress (tons per sq. in.) ..	36.8	38.5	35.8	37.7	23.4	21.6
Elongation (per cent on 2 in. gauge length) ..	20	18	22	25	29	23
Properties at 90 deg. to rolling direction						
Ultimate tensile stress (tons per sq. in.)	—	—	—	—	29	31
0.1 per cent Proof stress (tons per sq. in.) ..	—	—	—	—	23	20.3
Elongation (per cent on 2 in. gauge length) ..	—	—	—	—	30	21

Specimens E and F conform closely to D.T.D. 5033 for commercially-pure titanium sheet with an ultimate stress not greater than 30 tons. The ultimate stress of A, B, C and D is a little too high to fall into the limits of D.T.D. 5023.



(*c*) Bonderized by the Pyrene EP.1004 process. This is a proprietary treatment using a solution containing phosphate, fluoride and titanium ions at nearly boiling point(4).

(*d*) Sulphidized. The blanks were treated at 570° C. for times of 15 min. to 3 hours in a salt bath based on cyanide and sulphur compounds. A sulphur-rich layer is produced on the surface of the titanium.

Lubricants

The three lubricants used were :—

(*a*) Wakefield Dick DH2. A sulphonated fatty oil mixed with 43 per cent trichlorethylene. It was applied by immersing the blank and allowing it to drain on edge for one minute.

(*b*) Edgar Vaughan Tube Draw 40. A highly viscous chlorinated oil applied with a spatula in a thin layer.

(*c*) Trilac 455. This is an acrylic resin dissolved in trichlorethylene. It was swabbed on with cotton wool and allowed to dry for 10 minutes before drawing. A thin plastic film was left on the surface of the blank.

Lubricant, where used, was applied evenly to both sides of the blank. A few tests were also carried out using soaps, sulphonated tallows and molybdenum-disulphide compounds but the results were very similar to the results obtained with lubricant (*a*).

Press Tools

A flat-headed punch 2.0 in. in diameter with an edge radius of 0.250 in. was used for all the tests. The radius of the die was 10 times the metal thickness and a radial clearance of 50 per cent was allowed for the thickening of the blank during drawing. The general arrangement of the tools is shown in Fig. 4.

Preparation of Blanks

The blanks were prepared as described in " Proposals for standardizing the testing procedure for the Swift cup forming test "(1). They were guillotined from the sheet and turned to size.

Test Procedure

A standard drawing speed of 7 ft. per min. was used throughout the tests. The drawing speed will probably affect the test results slightly since information from Worcester (U.S.A.) Pressed Steel Co.[5] indicates slightly better drawing results on titanium alloys at $\frac{3}{4}$ ft. per min. than at 5 ft. per min. However Coupland and Wilson[6] suggest that the speed effect in deep drawing is very complex and should be considered together with lubrication. The quantity of material available was insufficient to investigate the speed effect.

A blank-holding pressure of 600 lb. per sq. in. was adopted for all the tests since it was found that at pressures below 500 lb. per sq. in. there was a tendency to wrinkle and that above about 650 lb. per sq. in. the ears tended to be torn out of the cup.

Fig. 4 (above).—General arrangement of the tools on the Swift press

Fig. 5 (right).—Types of cup failure showing, from left to right (a) *a cup with the " ears " torn,* (b) *a cup cracked on the punch radius, and* (c) *a cup that drew but failed on standing*

TABLE III—*Critical Blank Diameter and Loads of Titanium Drawn Under Varying Conditions of Lubrication*

Surface Conditions	Lubricant	Material Specification—Ti 75A								I.C.I. 130		HYLITE 10	
		A		B		C		D		E		F	
		blank dia.	maximum draw-load	blank dia.	maximum draw-load	blank dia.	maximum draw-load	blank dia.	maximum draw-load	blank dia.	maximum draw-load	blank dia.	maximum draw-load
Untreated	None	3.60	20.1	3.65	24.3	3.75	31.5	3.45	33	4.15	29.3	3.90	22.6
	DH2	—	—	3.70	27	3.75	31.2	3.45	31.5	4.15	28.5	—	—
	DT40	3.70	19	3.80	26	3.80	30.4	3.50	33	4.20	28.8	4.35	20.9
	Trilac	3.80	17.1	3.90	24.3	—	—	—	—	—	—	4.55	19.8
	Trilac + DT40	—	—	3.80	22	—	—	—	—	—	—	4.60	19.8
Oxidized	None	3.70	17.6	3.85	24.3	3.75	29	3.55	31	4.50	35.5	4.45	21.4
	DH2	—	—	3.90	25	3.85	30.5	3.60	31	—	—	—	—
	DT40	3.80	18.6	3.95	24.3	3.80	29	3.70	30.8	4.50	30.2	4.50	20.9
	Trilac	3.80	17.2	3.90	24.3	—	—	—	—	—	—	4.60	20.9
Bonderized	None	3.70	20.7	3.80	24.5	3.85	28.6	3.45	29.8	—	—	4.25	21.9
	DH2	—	—	3.80	25.7	3.85	31	3.45	29.3	—	—	—	—
	DT40	3.75	18.6	3.85	23.3	3.90	27.8	3.50	30.2	—	—	4.40	19.5
	Trilac	—	—	—	—	—	—	—	—	—	—	4.55	20.2
Sulphidized	None	3.90	19.5	4.05	25.7	3.90	29	3.85	33	4.90	30.3	4.70	21.4
	DT40	—	—	4.05	25.2	3.90	29	—	—	—	—	—	—
	Trilac	3.80	16.5	—	—	—	—	—	—	—	—	4.50	19.8

The blank diameters are given in inches and the maximum drawing loads are given X1000 lb.

Single blanks were tested over a range of blank diameters increasing in 0.050-in. increments. The aim was to find the maximum diameter of blank that could be drawn into a cylindrical cup without breaking. Owing to the shortage of material only two or three repeat tests could be carried out at the blank sizes around the critical size instead of the recommended five repeats. This might affect the accuracy of the results slightly.

RESULTS

The results are given in Table III. The critical blank diameter is quoted for each surface and lubrication condition tried, together with the average peak drawing load. The Limiting Drawing Ratio (LDR) may be obtained by dividing the blank diameter by two. The percentage reduction may be obtained by the formula :—

$$\frac{\textit{Blank diameter—punch diameter}}{\textit{Blank diameter.}} \times 100$$

For convenience a curve relating blank diameter with percentage reduction is given in Fig. 6.

An unusual feature that occurred with materials A, B and C was the cracking of cups that had been successfully drawn. The cracks appeared during a period of up to one month after drawing. The cracking did not occur if the cup was stress relieved after drawing and so a cup was said to be satisfactory if it stood for one hour without cracking.

The types of cup failure are illustrated in Fig. 5, which shows :—

(*a*) A cup with the " ears " torn.
(*b*) A cup cracked on the punch radius.
(*c*) A cup that drew but failed on standing.

DISCUSSION

Material

The results show that, in general, the materials may be placed in the following order of decreasing drawability : E, F, B, C, A, D. This is also approximately the increasing order of hardness or strength and the decreasing order of Erichsen value. The reason for the difference in properties may be explained by examination of the chemical

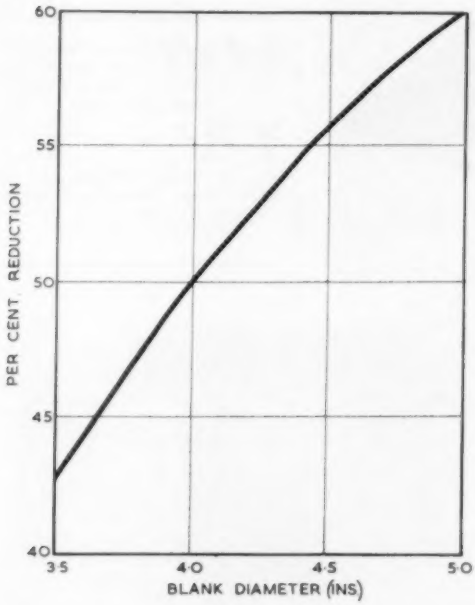


Fig. 6 (left).—Percentage reduction of cups drawn from different blank sizes

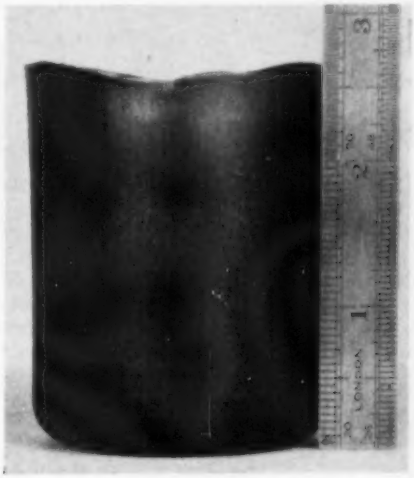


Fig. 7 (above).—Cup drawn from a sulphidized 4.90-in. dia. blank of material E

composition of the materials (Table I) when it is seen that the decreasing order of drawability is also the order of increasing oxygen content. There is little doubt that variation of the other elements that cause a marked increase in the hardness of titanium: *e.g.* nitrogen and carbon, would have the same effect.

It is thought that the post draw cracking (Fig. 5c) is due to the hydrogen content since the materials concerned (A, B and C) have hydrogen contents of 0.024 per cent or more. The cracking occurred only in very isolated instances in material D (0.015 per cent hydrogen). It is probable that the heat generated during working causes the hydrogen to dissolve and that failure occurs when the dissolved hydrogen reprecipitates at the grain boundaries in regions of high stress. If the hydrogen is removed before drawing by vacuum annealing or if the stress is relieved after drawing failure does not occur.

Surface Conditions

The four surface conditions examined may be placed in order of effectiveness as follows :—

1. Sulphidized.
2. Oxidized.
3. Bonderized.
4. Untreated.

Sulphidizing was the best surface condition examined, there being less to choose between the others. Using a combination of material E and a sulphidized surface, cups were successfully drawn from 4.90-in. diameter blanks (Fig. 7.) From the point of view of deep drawing there was no detectable difference between different sulphidizing treatment times from 15 min. to 3 hours.

It is interesting to note that a sulphidized treated surface is the only one not improved by the addition of a lubricant. The sulphidized surface layer may be removed, if desired, by a 2-minute treatment in sodium hydride without causing harmful increase in hydrogen content of the titanium.

Severe pick up and galling occurred on untreated titanium (Fig. 1) and also under some of the poorer lubrication combinations.

Lubricants

The lubricants tried may be placed in the following order of effectiveness :—

1. Trilac.
2. DT40.
3. DH2.

The Trilac appears to act almost as a surface treatment since the drawing results after application of Trilac are independent of surface condition. This is shown by the reduction in drawability of a sulphidized blank that occurs when the blank is coated with Trilac. The application of a lubricant to a Trilac surface does little to improve the results and may actually reduce the drawability slightly.

The plastic coat formed on the metal surface by Trilac protects the surface during handling and under certain circumstances complete sheets, as

Fig. 8 (left).—Pressed cover in DTD. 5023. The blank has been sulphidized and pressed at room temperature

Fig. 9 (below).—Drawn cup in DTD. 5023. Drawn cold from a sulphidized blank. (The hole is drilled after drawing)

received, may be coated by dipping and draining. Blanks produced from such a sheet require no further coating and may be drawn immediately.

The coating may be removed without trace by degreasing in trichlorethylene or by heating to 400° C. for 20 minutes.

PRESS-SHOP TRIALS

Experiments were carried out on several components manufactured from titanium sheet in the press shop.

One of these components was a pressed cover illustrated in Fig. 8 and another was a cup drawn with a curved base, Fig. 9. Both these components are normally drawn at 500° C. using molybdenum disulphide as a lubricant. Using normal lubricants these pressings cannot be produced at room temperature.

Both components were successfully pressed in the cold using a sulphidized treated blank without additional lubrication. Other Trilac coated blanks drew at room temperature without lubrication but it was found that after a long run a plastic coating built up on the tools and eventually lead to scoring. To avoid this effect frequent cleaning of the press tools would be necessary which would not always be convenient.

One disadvantage of working titanium at room temperature is that "spring-back" becomes an important factor. The procedure adopted at present to overcome this trouble is to hold the pressing in the heated dies for one to two minutes after the dies have fully closed. If components were produced without heating the blanks, allowance would have to be made for spring-back which could vary with different batches of material.

Conclusions

1. The impurities present in commercially-pure titanium have a pronounced effect on the drawability. The samples examined were particularly sensitive to oxygen content.

2. The samples having more than 0.015 per cent hydrogen were susceptible to post draw cracking.

3. A high blank-holding pressure in the order of 600 lb. per sq. in. is necessary and can be varied only within quite narrow limits.

4. A sulphidized surface gives the best drawing results. This involves treating the blanks in a salt bath. The application of Trilac on the untreated surface is almost as effective.

5. Press-shop trials have confirmed the results obtained on the Swift press.

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ROTHERHAM TECHNICAL COLLEGE EXPANDS

SHEET metalwork students are among those who have moved into the first of new extensions at Rotherham Technical College. This is the workshop block, the first of four blocks to be constructed. There will eventually be mechanical engineering workshops and laboratories on the top floor and on the second floor is a welding shop which is being equipped but not yet in use.

WORKING METALS BY DETONATING EXPLOSIVES

By J. H. COOK*

(*A paper presented at the Annual Conference of the Institute of Sheet Metal Engineering, London, November* 11 *and* 12, 1959.)

THE recent application of explosives to fashioning metals does not signify that explosives have suddenly become precise instruments for doing work. Explosives have always been precise instruments but, in their common use the information which is generally lacking is the strength of the materials on which the explosives act. Nevertheless in planning a quarry blast, or in the winning of coal, or in the other numerous applications, where disruption is the goal, an explosives engineer calculates, from precise data, the type and quantity of high explosive which will suffice to take the material to be blasted beyond its elastic limits. He then adds a quantity to the determined charge so that he has a working margin, a step which is common in all engineering practice. By this means he ensures that a satisfactory disruption is achieved.

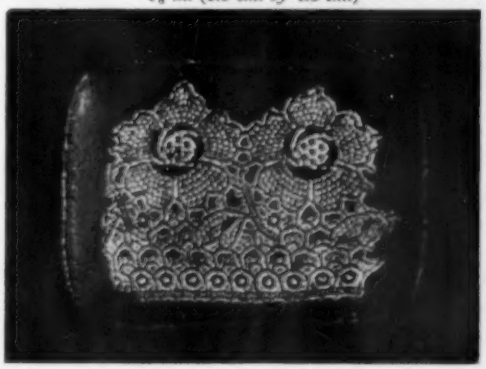
The term high explosive has been used which suggests that there is more than one type of explosive. This is true and explosives may be classified in several manners, but, for the present purposes, they will be classified in two groups : (*a*) propellants or burning explosives, and (*b*) high or detonating explosives.

The two different types of explosives demonstrate two differing mechanisms of propagating a chemical reaction. The reaction in a burning explosive is propagated by thermal conduction where the chemical reaction is rapid and may propagate at speeds not exceeding 300 metres per sec. The method of propagating the reaction in a detonating explosive is totally different. A pressure pulse is initiated in a detonating explosive by means of a detonator, or some similar initiating device, and this pressure pulse triggers a chemical reaction in the explosive. The progressive chemical reaction in turn sustains the pressure pulse in its passage through the column of explosive. The pressure pulse in a detonating explosive can travel at velocities within the range of 1,000 metres per sec. to 9,000 metres per sec. approximately. Burning explosives are capable of generating pressures with a maximum of 60 tons per sq. in. approximately, whereas the detonating explosives are capable of giving pressures ranging from a few tons per sq. in. to more than 1,000 tons per sq. in.

Burning explosives have certain applications in metal working such as the Cox's Submarine Gun for driving bolts through metal plates, but the present paper has been limited to the application of detonating explosives to metals because that field is more novel. Burning explosives are also limited in their application because they function best under good confinement in contrast to detonating explosives which can apply high pressures with no assistance from external confinement.

It was indicated earlier that the properties of detonating explosives were readily defined ; consequently if the object on which the explosive has

Fig. 1.—*Engraving on steel plate. Pattern size* 2½ *in. by* 1⅞ *in.* (6.3 *cm. by* 4.8 *cm.*)



* I.C.I. Ltd. (Nobel Division)

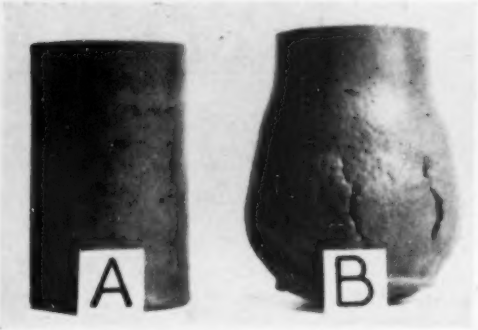


Fig. 2.—Demonstration of pulsed shotfiring in water. Similar sized charge in Pot A and Pot B, but charge in Pot A is surrounded by air whereas charge in Pot B is surrounded by water

to do work could also be defined, or determined, then it should be possible, within limits, to prescribe an explosive for certain precise tasks. This feature has been known to a certain degree for more than half a century and reference can be made to work by Munroe[1] where he reports imprinting the design of a leaf on a metal plate by means of explosive. A better specimen of old engraving is available at the Ardeer Factory of Imperial Chemical Industries where a small reproduction of the pattern in lace is made on steel by an explosive charge. Fig. 1 shows the engraved steel plate. The age of this engraving is not certain, but it was made in the early years of this century.

The problem of working metals by detonating explosives resolves itself into determining the conditions where the requisite charge of explosive will do the required job, no more or no less, with as little undesired deformation as possible of the metal. When in the past the metals to be shaped were workable by available mechanical means and where the shaping was straightforward there appeared no necessity for unusual methods of fabrication, but with the recent advent of metals of unusual properties, and whose shaping was desired to be unusual, it became necessary for metallurgists and engineers to consider any technique which was available and which would assist them in their fabrication problems. The Americans have been very alert in this field as can be seen by the prolific literature publications. Interest has arisen in this country within the past two years and a few examples will be described of known effects of the working of metals by detonating explosives.

Forming or Shaping Metals by Detonating Explosives

When a detonating explosive is fired directly on a metal plate it will either deform it locally or disrupt it; therefore, in shaping a metal plate,

Fig. 3.—Shaping of 28/1,000 in. copper sheet. Bowl 4 in. dia. by 1¼ in. deep

it is desirable for control purposes that the explosive should be some distance remote from its target. The direct explosive pressure through air over a wide area, and such wide areas would eventually be desired for practical applications, is not readily controlled because the intensity of the pressure pulse is quickly degraded in its passage through air. However, if the explosive charge is fired in water and it is arranged that the water is in contact with the metal to be shaped, then by suitable arrangements of the explosive charge a uniform pressure can be brought to bear on the metal to be worked.

The above principle has been used for decades by explosive engineers who had to disrupt scrap vessels, such as acid pots, in a built-up area. A determined charge of explosive was fired in the water filled vessel. The vessel merely collapsed. Again since the recent war explosives engineers have developed an explosive/water technique for obtaining large coal, a method which incidentally increases the safety factor in coal mining. The method is described as Pulsed Infusion Shotfiring[2]. Water is infused into a borehole in the coal and the explosive charge is fired with water surrounding it. The method has been found to be successful in suitable seams of coal. An appreciation of pulsed infusion shotfiring can be obtained from Fig. 2. A similar-sized charge of explosive is fired in two similar-sized lead pots. In one pot, A, the charge is surrounded by air and in the other pot, B, the charge is surrounded by water. Fig. 2 shows the effect on each pot after firing the charge. Pot A has retained its shape whereas pot B has been deformed. This simple experiment has been used frequently during the past decade in demonstrating the principle of Pulsed Infusion Shotfiring to coal mining engineers.

In the three examples quoted of Pulsed Shotfiring in water, it was arranged that the charge would disrupt the selected target. Should it be desired merely to deform a selected metal target, then the charge, as one of several variables, could be reduced in size. Again should the required deformation be of a desired shape then the target could be enclosed in or on a suitably designed mould. The target could be filled or covered with water and the explosive charge fired in the water. The pressure

pulse would then shape the target to the mould. Successful shapings have been achieved by this method and a small example is shown in Fig. 3. Probably the most troublesome feature of the method is the removal of any residual air between the target and the mould. The air acts as a cushion which prevents true deformation. The air cushion can be removed by arranging a suitable air escape or by evacuation.

The suitability of this method for metal forming will have to be decided by interested parties. At present several establishments have the matter under consideration.

The quantity of explosive required for relatively large shapings would be small, consequently the shot-firing operations would not disturb the populace nor cause damage to property.

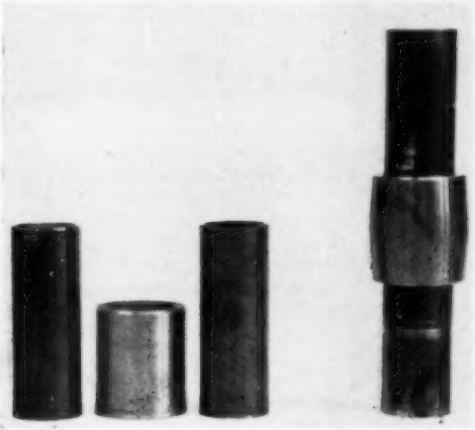
Jointing or Welding of Metals

A method can be applied for the jointing by explosives of two metal tubes in a common collar, the method being very similar to that used in the shaping of metals. The collar can be considered as the mould and it is slightly greater in internal diameter than the external diameter of the tubes to be jointed. The tubes and the collar are assembled in what will be their final position. Water is poured into the tubes. When the explosive charge is fired within the region of the common surfaces of the tubes with the collar then the tubes are expanded into the collar. Successful jointings have been made which are mechanically rigid. Simple joints of this kind have been found to be waterproof at ordinary pressures but not at high pressures. The fabrication of joints for work at high liquid pressures should, however, be possible, because there is scope for varying the intensity of the explosive pressure. Fig. 4 shows a simple watertight joint made from two lengths of copper piping in a collar of stainless steel.

The jointing of tubes or plates to make gas-tight joints would be a more difficult task because that would demand a degree of welding. No reliable explosive/welding technique over a wide area is known, although metallurgists have given a good appreciation of the welding over small areas. Welding demands a physical change in the surfaces to be welded. Should it be found impossible to achieve a satisfactory welding technique by the pulsed water technique then recourse could be made to the direct application of explosive pressure to the selected surfaces.

The quantity of explosive used in the jointing process is small in relation to the size of the job and the firing operation would provide no hazard to property. A satisfactory welding operation would demand a larger explosive charge for a similar sized job.

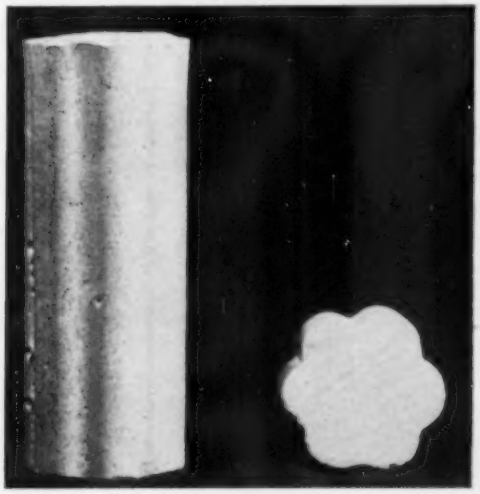
Fig. 4.—Jointing of two lengths of copper piping 1¼ in. internal dia. by 1½ in. external dia. in stainless-steel collar 1½ in. internal dia by 2 in. external dia.



Compacting of Metal Powders

Detonating explosives are commonly considered to be devices for destructive purposes. Within recent years it has been possible to apply them to purely constructional purposes. It is well known that some of the metals now being used in industry are very chemically active at high temperatures and consequently it is difficult to obtain them in ingot form for further operations. Several years ago the problem of compacting metal ingots from the metal powder was submitted to explosives

Fig. 5.—Compacting and shaping of metal powder in the one operation. Shaped cylinder of aluminium powder 1¼ in. dia.



technologists. The problem was tackled and it has been solved successfully.

Titanium is an example of a metal which has been compacted successfully into a solid ingot. The density of one ingot, 4½ in. in diameter, was 90 per cent of the absolute density of the metal. The density of the starting metal powder was 1.4 gm. per cc. and that of the ingot was 4.0 gm. per cc. A greater density in the ingot could doubtless be achieved if desired.

The method consisted of subjecting a cylindrical column of powder to a simultaneous uniform pressure over its curved surface area. The pressure would be several hundred tons per sq. in.

In the course of preliminary work it was found possible to shape the ingots to a degree at the same time as the metal was being compacted. Fig. 5 shows a column of aluminium powder which was compacted with some flutings—all in the one operation.

The weight of the explosive charge for compacting large ingots would be classified as large in relation to the weight of metal. The application of the method to large ingots would therefore require to be performed in a secluded area which had a plentiful supply of water.

Engraving on Metals

Detonating explosives are not usually associated with artistic reproductions but again their versatility can be demonstrated by showing that they can reproduce a delicate design on metal plates, just as delicate as any other technique or art.

It was stated in the introduction that Munroe, six decades ago, and Nobel's Explosives Company, at a somewhat later date, made small engravings on metals.

Just after the recent war the problem of making large engravings was tackled. The method which was developed has been described previously[2]. It consisted essentially in applying a uniform high pressure to a stencil which was placed on top of the metal to be engraved. The development of the method at first proved troublesome for large engravings, because the pressure wave from a normally initiated explosive charge is approximately spherical and, consequently, when the wave is applied to a stencil on a flat surface it causes distortion in the reproduced design. However, by application of what is known as a plane wave front it is possible to obtain a true reproduction, over a wide area, of the stencil design. Engravings, in which the stencil pattern is reproduced faithfully on the metal plate, have been made over 20 in. square areas, and the method would permit of still larger engravings. The stencil can be fabricated from simple destructible materials of different shapes and thicknesses. Fig. 6 shows an example of such an engraving. In the application of the explosive pressure the metal plate is hardened.

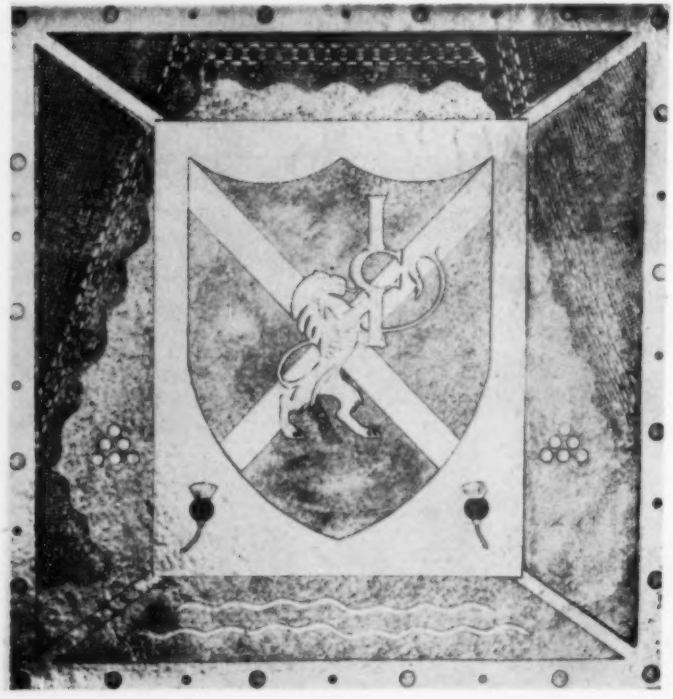


Fig. 6.—Engraving on ⅛ in. (0.3 cm.) thick brass plate 20 in. (50.8 cm.) square

The explosive charge for large sized engravings is high which necessitates that the shotfiring should be done at a remote site.

It should be possible to make the engravings on any hard metal.

No practical application has yet been adapted for this engraving technique although consideration has frequently been given to it.

Successful engravings on metal have also been made by the pulsed water technique, but so far without the elegance of the other method.

Hardening of Metals

When explosive pressures up to 1,000 tons per sq. in. are applied directly on a metal it is readily understandable that hardening of the metal surface occurs. This feature is generally accepted. Recently claims have been made in an American patent that the hardening can be made to controlled depths in the metal. The extent and depth of hardening, as claimed by the patent, depend on the thickness of the sheet of plastic explosive used and its intimacy of contact with the metal.

Cutting Cast Iron

The cutting of a sample of cast iron by conventional methods from within a large area of the metal is apparently a very uncertain operation. The cast iron is liable to break along undesired lines. It has been found possible to make, by detonating explosives, precise cuts in cast iron fittings so that the samples follow the desired pattern without any undue deviation.

The cutting method consists in firing a small charge of explosive along the outlines of the pattern.

The Cutting of Metal Plates and the Boring of Holes in Metals

The shaped or hollow charge is a device whereby the pressure from an explosive charge is focused on a point or a line. The effectiveness of a shaped charge has been known for more than half a century, but it found no wide use until it was adapted for assault demolition purposes in the second world war. After the war the adoption of the shaped charge for commercial purposes was considered[4], but without any manifest success, except in the tapping of blast furnaces.

The introduction in industry of the new robust metals has produced some difficulties in cutting or drilling operations. The use of the shaped charge for these purposes is being examined. Nimonic 75 metal, 6½ in. by 1 in. bar, has been cut successfully, as shown in Fig. 7. The cut was clean but not too elegant.

Holes have also been bored in strengthened steels. Again the holes were not too elegant. However, the shaped charges used in these operations were not designed for elegant work ; they were designed for robust demolition duties. Should any precise cutting or drilling operation be found for shaped charges then the charges could be designed and manufactured with more precision. The length and weight of the shaped charge would depend on the nature of the work it had to perform.

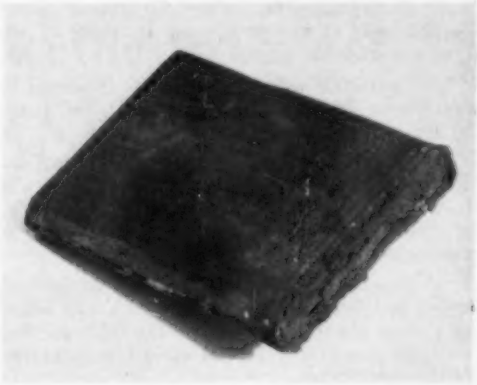


Fig. 7.—Cutting, by shaped charge, of Nimonic alloy 75, 6½ in. by 1 in.

Discussion

The examples which have been cited for working metals by explosives may prove to be of practical interest to metallurgists and engineers. Consequently an appreciation is now given of some of the factors which will be important to potential users of the applications. The essential factors in the methods are discussed under separate headings.

(*a*) *Safety.*—Explosives are generally considered to be hazardous devices. This is unrealistic, because the people who use explosives, such as shotfirers in coal mines and in quarries, have one of the lowest frequency of accident rates in industry. Detonating explosives have a high power potential, but, when that is realized, operating with explosives is very safe.

(*b*) *Simplicity of Operation.*—The shotfirer's equipment required for exercising high pressures by detonating explosives, for most of the projected uses, would consist of a few pounds of explosives, a few detonators, a length of firing cable, an exploder and a galvanometer ; in all, a total weight of the order of 10 lb.

(*c*) *Portability of Method.*—Following on from (*b*) it will be seen that the explosive equipment is portable and that the " tool " can be carried to the job, a feature of which is not usual in the normal working of metals.

(*d*) *Disturbance Effect.*—The disturbance caused by shotfiring is momentary and in most of the cited cases would be small.

(*e*) *Type of Metal to be Worked.*—It should be possible to fabricate most types of solid metals by the explosive technique.

(*f*) *Type of Explosive.*—The range of power and velocity of detonation of available explosives is very wide. Consequently in deciding on an explosive for a particular task, the operator can be very selective.

(*g*) *Precision of Methods.*—The various methods which have been described permit of a high degree of precise manipulation. How far these methods are satisfactory will depend on the requirements of the specification.

(*h*) *Cost.*—This most important factor should favour the use of explosives. Their cost should be small in relation to the cost of a machine or the depreciation value of that machine.

(*i*) *Development.*—Any development of the explosive technique in the working of metals is visualized as a combination between the demands of the interested parties in the metal industry and the knowledge of the explosive technologists.

In conclusion, the author wishes to make acknowledgement to Mr. W. T. Montgomery and other members of the staff at the Research Testing Station, Ardeer Factory of the Nobel Division, Imperial Chemical Industries, who did most of the experimental work.

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DISCUSSION

Dr. WALLACE asked whether the production of the heraldic shield could not have been achieved more easily by the shot-blast gun than by the use of explosives.

Mr. COOK said that he did not think that the same depth of engraving would have been obtained. It was possible to obtain a depth of engraving of 0.010 in. quite readily with explosives.

Chemical Products of Explosion

The CHAIRMAN (Dr. W. E. HOARE) said that he had been interested in what Mr. Cook had said about the use of explosives for compacting metals, particularly in connexion with the more reactive metals. Were the chemical products of the explosive insulated from the powder ?

Mr. COOK said that the chemical products of the explosive were quite harmless ; in fact, with a good explosive they were only carbon dioxide, nitrogen and water. The container for the powder, which was compressible, would prevent the entry of the gases into the compacted mass.

Mr. BROUGHTON (Ministry of Aviation) asked whether it was necessary for special facilities to be constructed to carry out the limited work which had been done in this range, for example, pits or specially constructed jigs.

Mr. COOK said that his organization had a testing station with many devices available, but no special equipment was required for the work. There were other types of explosive, which he had not discussed, but a detonating explosive would liberate its pressure without any mechanical confinement, so that one did not need expensive equipment.

Mr. BAKER (Gillette Industries Ltd.) asked what was the time delay involved between the initiation of the firing pulse and the propagation of the shock wave.

Mr. COOK said that the velocity at which a detonating explosive propagates was between 1,000 and 9,000 metres a second. There was therefore no appreciable time lag in the propagation of the shockwave.

Production Speed for Simple Cup Draw

Mr. E. MORGAN (Metal Box Co. Ltd.) asked what the speed of production would be for drawing a simple cup, such as that illustrated in the paper.

Mr. COOK replied that the time for producing it was practically instantaneous, but the setting up of the equipment would have to be worked out according to the job under consideration.

Dr. WALLACE said that in support of explosive forming it was well known that when deforming at high speeds dislocations or work hardening did not take place. Was a blank put on top of the component to prevent flange wrinkling, or was the pressure wave sufficient to prevent it, or was there a blank-holder ?

Mr. COOK said that with a charge which was specially designed it was possible to arrange a set-up so that the charge functioned as required on selected surfaces but had no effect on other surfaces. It should not be assumed that hardening did not take place in the explosive forming of metals.

Mr. J. E. ROBERTS (Colvilles Ltd.) asked whether that applied in the Pellini test.

Mr. COOK said that it did, and asked whether Mr. Roberts used it, to which the reply was that the test was used on the steels produced by Mr. Roberts's firm.

Investigations into the Wear of PUNCHES AND DIES

By Dr.-Ing. W. CRASEMANN*

(A paper presented at the Annual Conference of the Institute of Sheet Metal Engineering, London, November 11 and 12, 1959.)

FOR several years investigations into the wear of punches and dies has been proceeding at the institute for "Werkzeugmaschinen und Umformtechnik" of the technical university of Hannover, the main results of which are summarized in this paper.

However, before discussing wear itself, it is necessary to give some explanation about shearing of sheet metal. When shearing with a punch and die, two edges with a certain clearance in between are being pressed into the sheet, resulting in a bending-moment which tends to lift the internal part of the sheet off the punch and the external part off the die. Accordingly there will be a pressure on the face of the tools, which will start some distance in from the edges, depending on the cutting conditions, and which increases swiftly to the edge (Fig. 2). The pressure depends on the shearing load and on the flexibility of the sheet, which itself depends on the ratio of tool-diameter to thickness of sheet.

When tools penetrate into the sheet, the material between the edges is deformed plastically until the material starts cracking at the most strained parts near the edges and cracks finish the cut (Fig. 1).

* Lehrstuhl und Institut für Werkzeugmaschinen und Umformtechnik, Hannover.

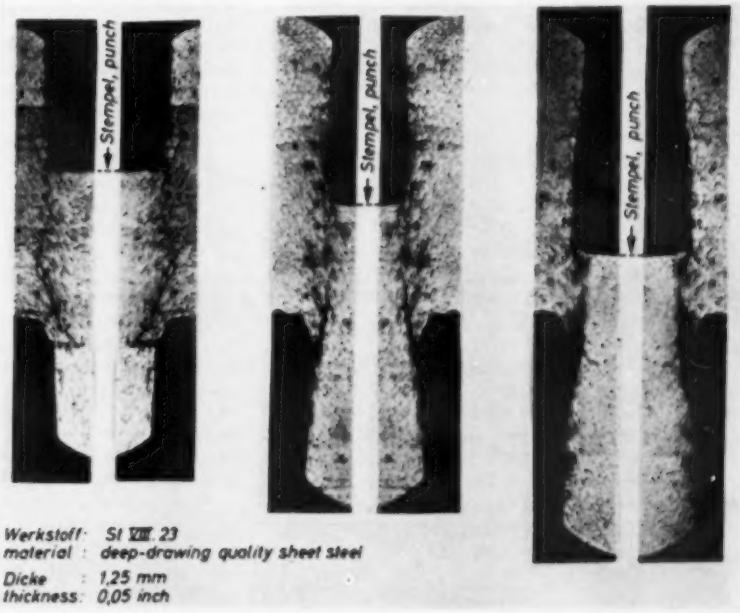


Fig. 1.—Graduation of shearing

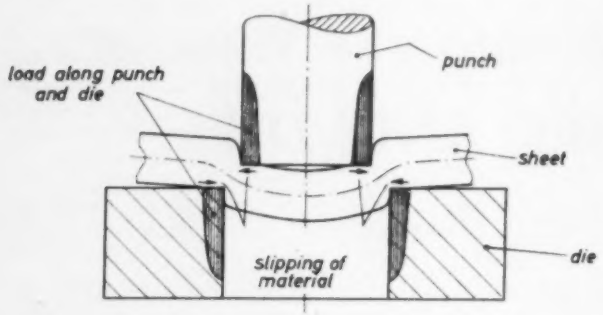
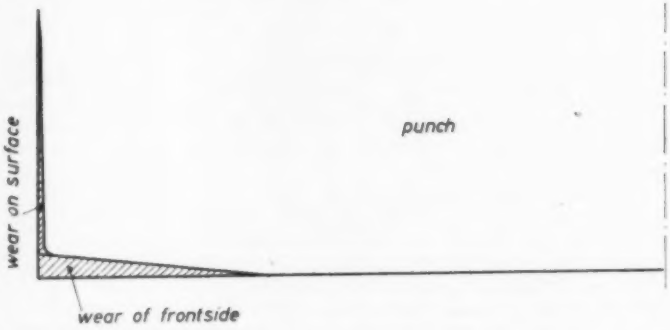


Fig. 2 (left).—Load along punch and die

Fig. 3 (below).—Wear on front and surface of punch after 100,000 cuts



Following plastic deformation, material flows over the face of the tools towards their edges. This slipping of the material over the face of the tools and also the pressure there both cause wear on the face of punches and dies; in German this is called "Stirnflächenverschleiss" or "frontwear."

If the slipping of material over the face of the tools is of any importance to the abrasive effect on the tools, measures to reduce slipping, for example, using rougher tools, should result in less wear. In fact, investigations have confirmed this assumption and the published results have been verified by many factories. In practice it means that expensive lapping or polishing of tools is not only useless but even a disadvantage especially when cutting tough materials.

In addition to the "frontwear"—"Stirnflächenverschleiss"—wear was also observed on the curved surface area of punches and dies or their internal ring area. In German this is called "Mantelverschleiss," translated perhaps by "surface-wear" (Fig. 3). It is the result of the pressure on the surface, caused by plastic deformation of the material between the edges. Cutting thin sheets, the wear at the surface is less important as compared with the wear on the face

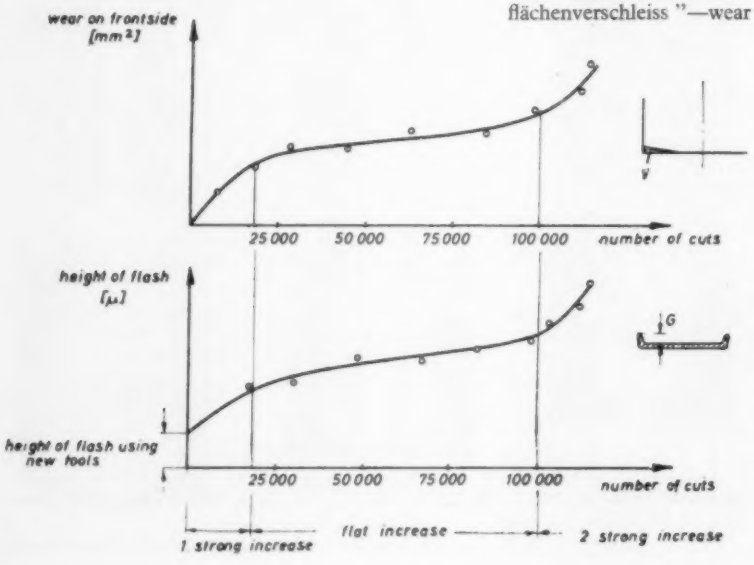


Fig. 4.—Increase of wear and flash depending on number of cuts

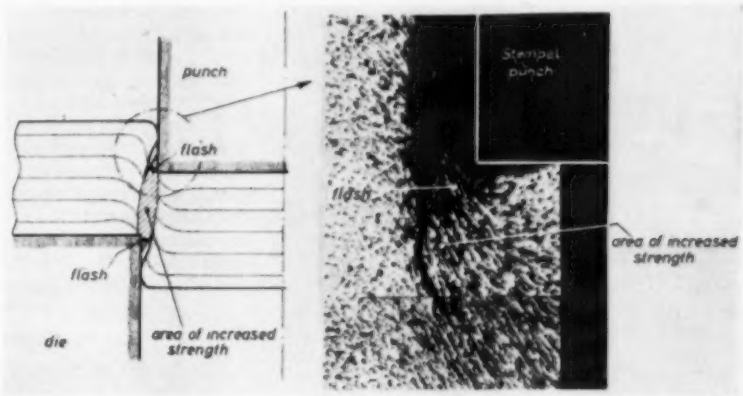


Fig. 5.—Development of flash by shearing

of the tools. Therefore, this paper will be devoted to the wear on the face.

Comparing tools with respect to the wearing resistance of their edges, *i.e.*, their resistance to wear during a certain number of cuts, a criterion or a basis is necessary. *W. Kienzle* has used as basis the volume of metal which is removed from the face of the tools due to wear. But instead of the volume itself, he took the cross-sectional area of the punch as shown in Fig. 3 as a basis. This area can be exactly measured by a surface measuring instrument, for example, the Leitz-Forster instrument.

From Fig. 4 the wear on the face of the tools is shown to depend on the number of cuts. At first a strong increase of wear is observed; then the increase of wear becomes smaller so that the tools will be worn out less during the next few thousand cuts. But then the wear becomes heavier again and usually to a greater extent than the first increase. This curve can be interpreted as follows: During the first cuts the front of the tools touch the sheets with a small edge only. Therefore, the shearing-load is concentrated on a small area only, resulting in heavy wear due to high pressures. With growing wear the contact area of the tools becomes bigger so that pressure is reduced and the wear becomes less. In the meantime, however, the slipping of the material on the face of the tools is growing and the tools penetrate deeper into the material before it starts cracking. The result is that the material is deformed more and more plastically so that the hardness of the material increases and therefore pressure increases too. Both influences, increased slipping and increased strength of material finally result in another strong increase of wear.

So far the worn-out front portion of the tools only has been considered, but the tool profile also changes. It can be observed that the tools near the edges become conical, but the edges themselves still remain sharp. This may explain the fact that the shearing-load scarcely increases with the number of cutting strokes. Measurements have shown that the increase of the shearing-load is rather small as compared with the fluctuation resulting from variation in thickness and hardness of material. Therefore, it is not correct to determine the wear-conditions of the tools by the measurement of shearing-load, although this has been proposed by some authorities. On the other hand, the change of tool profile does influence the amount of flash produced, and this is very important. The formation of flash can be explained as follows:

When tools penetrate into a sheet, the material is stretched, particularly right in front of the edges within the clearance. So an extensive area of hardened material is formed within the clearance, which resists any cracking (Fig. 5). Therefore, the material does not crack directly on the edges, but at a certain distance from them and the flash is a part of the hardened area. This will be increased by blunt tools, because they go deeper into the sheet before cracking starts and the hardened area becomes still more extensive.

Comparing the increase of wear and of the flash in relation to the number of cuts, both curves at first increase then they become flatter, but finally they increase strongly at about the same number of cuts. Therefore, it is possible to recognize the second strong increase of wear by simply measuring the flash. This is very important in order to find out the right moment to regrind the tool; if the tools are used without regrinding after the second strong increase of wear has started, it would be necessary to recondition them so extensively that they would be worn out very soon.

Measurements of wear are of practical importance, first, to examine the possibilities of how to shear sheet metals, and second, to examine the resistance of tool materials against wear.

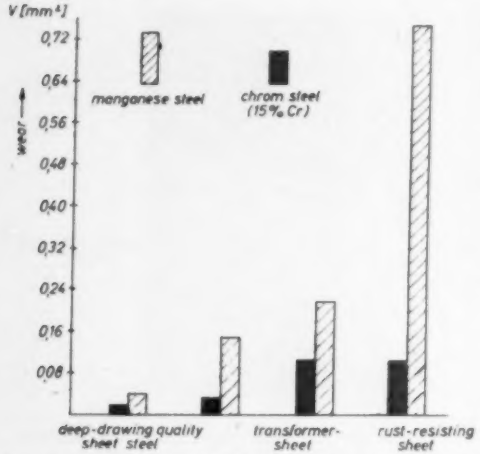


Fig. 6.—Wear after 100,000 cuts and tool-steel/sheet-material

There is also the question of whether a short-term test procedure is applicable. Investigations have shown that some tools that wear out more rapidly at first may show less wear after a great number of cuts than those tools which had a small wear at first. But because the beginning of the second increase of wear is important a large number of cuts, *e.g.*, approx. 100,000, are necessary for proper examination. Judging the shearing possibilities of sheet metals it is necessary to consider the gradual wearing effect on the tools and the tendency to form flash. The formation of flash is important too, because there are many articles where the acceptable height of the flash is limited. Investigations have shown that it is possible that sheet metals which have less wearing effect on tools may have a higher flash than those with more wearing effect. This is understandable, because in addition to the wearing effect on tools there are other material characteristics important to the formation of flash, for example, their yield, their tendency to harden, and so on. Therefore, to judge the shearing possibilities of sheet metals it is necessary to observe both the wear-curve and the flash-curve in relation to the number of cuts.

To check the wearing resistance of tool materials only the wear-curve is important. Investigations by *W. Kienzle* have shown a strong mutual influence between the sheet metal and material of tools. For instance, in 100,000 cuts the wear of a low-alloy tool steel is twice as heavy when cutting rust-resisting qualities of sheets as of a 15 per cent chromium-alloy tool steel. Cutting deep-drawing quality sheets the wear resistances of the tool steels fluctuate between 0.7 to 3.0 (Fig. 6).

These results are of practical importance, because, for example, Cr-alloyed tool-steels are not so economical for cutting deep-drawing sheets as for cutting transformer sheets. But in cutting rust-resisting materials the more expensive 15 per cent Cr-alloy tool steel is absolutely necessary.

Checking tool-steels it can be seen that the sheet metals, which they are used are of special importance. Therefore, it is necessary to examine each tool-steel along with several sheet materials. According to the author's experience, however, it is sufficient to examine a tool-steel for shearing by using a deep-drawing quality sheet, a transformer sheet and a rust-resisting quality of sheet.

Summary

On the face of punches and dies and on the side of punches or the internal ring of dies, wear takes place by slipping of sheet material under pressure. Shearing thin sheet metal the wear on the face of tools is much larger than the wear on their surfaces.

As a result of the wear on the face of tools the punches and dies become conical near their edges, but they still remain relatively sharp. This change of the tool-profile results in only a slight increase of the shearing-load, but a heavy increase of flash.

In relation to the number of cuts the wear of tools and the flash increase similarly. Therefore, it is possible to assess the wear of tools by simply measuring the flash.

It is not possible to say how the wear and flash curve will develop by considering only the initial inclination of such a curve. Therefore, it is imperative to check the wearing resistance of edges after a large number of cuts.

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DISCUSSION

Dr. J. F. WALLACE (Sheffield University) said that Dr. Crasemann's paper must have involved very laborious work. He wondered whether all the blanks which Dr. Crasemann and his colleagues had produced had been made economically and whether they had found a market for them.

Referring to Fig. 6, he asked whether, if the blanking tests on deep-drawing quality sheet steel were carried into millions instead of 100,000 as in the figure, the comparison between manganese steel and chrome steel would be similar to that in the case of the rust-resisting sheet. Was the fact that the manganese steel was very little different from the chrome steel in that case due simply to there

(*Continued in page* 266)

Industrial Applications of HIGH-SPEED CINEMATOGRAPHY

By JOHN HADLAND*

(*A paper presented at the Annual Conference of the Institute of Sheet Metal Engineering, London, November* 11 *and* 12, 1959.)

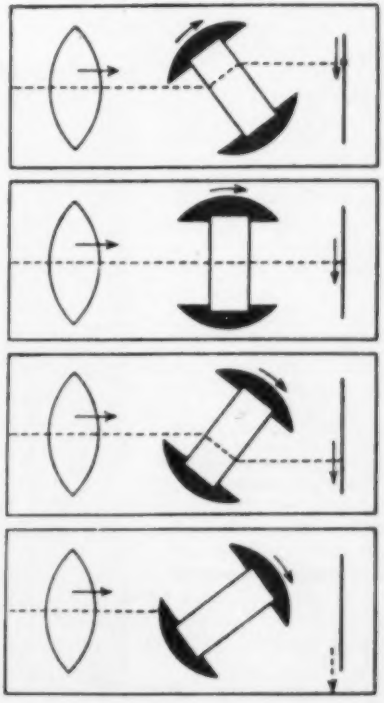
HIGHER industrial production calls for higher speed machinery. As the speed of process increases, faults become harder to see and understand. How often a development engineer is forced to say, " If only it was going slower, we could see what is going wrong ! "

High-speed cinematography is the taking of high-speed motion pictures to record permanently for study and analysis, phenomena too fast for the eye to discern. By taking pictures at a rate many times faster than the normal projection speed, an ultra-slow motion film is made which, when shown on the screen, reveals events hitherto lost in the blur of speed.

The normal film camera has an intermittent action. The film is exposed when stationary, a shutter stopping light from reaching the film when it is in movement. Such cameras usually are made to take photographs at the rate of 16 pictures every second, and the film when developed is subsequently projected on to the screen at this same rate. Thus, what takes one second to photograph, takes one second to show on the screen. If the camera is speeded up, to take 32 pictures every second, then at the normal projection rate of 16 pictures per second movement is slowed down, for the actions of a second are shown as lasting two seconds on the screen. The ordinary intermittent camera can be speeded up so that it will take as many as 320 pictures every second, and it is, therefore, capable of exposing a film which will show any action slowed down 20 times. Many industrial processes require a very much higher degree of slow motion before they can be properly understood and special cameras have been designed which will operate at the higher picture taking rates required.

A film camera mechanism which makes use of the intermittent movement of film cannot be speeded up beyond 320 pictures per second because the tremendous acceleration forces which are applied to the film cause it to rupture. Thus high-speed film cameras make use of a continuous film movement, passing the film directly from its feed spool to its take-up spool past the camera lens, and employing various ingenious devices which allow sharp pictures to be taken. The best of these devices consists of a rotating block of glass which is situated between lens and film and bends the light from the lens so that it moves at the same

Fig. 1.—*The principle of the rotating refractor image compensator as used in the Kodak and Wollensak Fastax high-speed cameras*



* John Hadland & Co.

speed, and in the same direction, as the film passing by. A diagram showing how this image compensator works is shown at Fig. 1. In the first sketch, light from the lens is bent upwards, coming to a focus at the top of the gate ; in the second diagram, light passes straight through the optical plate without being bent at all ; and in the third diagram it is bent down towards the bottom of the gate. In the fourth diagram, shutter blades which obscure the end of the glass plate have cut off the light and this allows for the correct spacing of the pictures on the film. This rotating prism principle was incorporated into a camera made by Eastman-Kodak in 1932 and used in the San Francisco Olympic Games for race timing the following year.

There is no reason why the refractor should have only two working faces, and in the Bell Telephone camera, which was developed at about the same time, a four-sided prism was used, and subsequently an octagonal prism was developed. Using a principle of this type, the limits within which one can take pictures are only those of, first, how fast is it possible to rotate the compensator, and second, how fast is it possible to move the film.

In the Eastman Type III high-speed camera the film is moved at the rate of about 70 ft. per second, and the maximum camera speed is a little over 3,000 pictures per second. In the Bell Telephone camera, which has subsequently been improved and re-designed and is now marketed by the Wollensak Optical Company of Rochester, U.S.A., the film is moved at the tremendous speed of 250 ft. per second, and the maximum framing rate on 16-mm. film is 9,000 pictures per second. The Wollensak camera, marketed under the trade name of Fastax, also makes use of an octagonal prism. It takes photographs, which are half the normal 16-mm. format height but the full 16-mm. width, at the rate of 18,000 pictures per second. Fig. 2 shows the most recent development in this field of the optical compensator type of camera.

Using high-speed cameras of the type described it is possible to make film records of industrial processes in which the speed of movement is slowed down as much as 1,000 times. The events of 1/10th of a second being subsequently shown on the screen as lasting almost two minutes. As a microscope stretches the linear dimensions, so the high-speed camera can be regarded as a " time microscope," revealing design weaknesses, which have hitherto been lost in a blur of speed.

Until recently, the majority of cameras in daily use have been busy on defence projects.

Since 1956 there has been a gradual realization by industrialists that the technique of high-speed cinematography has much to offer them, both in the improvement of existing machines and the design of new ones.

In the United Kingdom in 1958 more high-speed cameras were being used in industrial research laboratories than on defence projects. Twenty companies in this country have set up

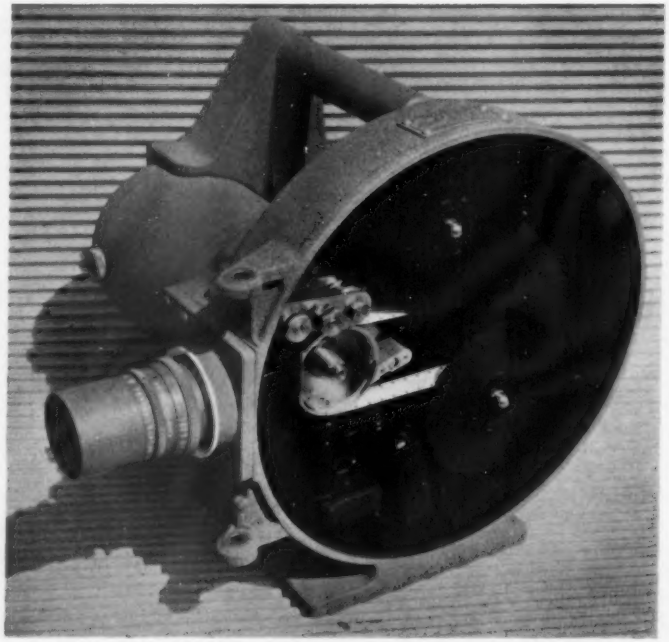


Fig. 2.—The Wollensak Fastax W.F.3 high-speed camera capable of all speeds between 150 and 18,000 pictures per second

their own high-speed cinematography laboratories, employing experienced technicians who, working in close co-operation with the design and development engineers, are called upon to help whenever the project under examination moves too fast for the eye to follow. Many other high-speed cameras are held in photographic departments, where the photographer concerned finds no special difficulty in using a camera which may well be running 1,000 times faster than the one to which he is accustomed.

The industrial use of high-speed cameras is the author's special concern. During the past 15 years more than a million feet of 16-mm. film has been exposed, helping industrial research laboratories to solve many problems. Of recent years the author's company has been active in supplying and installing high-speed cameras, and training technicians in their use. Industry in the United Kingdom is now setting up high-speed cinematography groups at the rate of about 20 per year. Every day an increasing footage is passing through high-speed cameras, so that the special requirements are now recognized and catered for by the film manufacturers and processing laboratories.

Twenty-three of the major industries in the United Kingdom use rotating prism high-speed cameras in one way or another. In the past year, the technique has been used in many ways, some of which are described below.

In the automobile industry, high-speed cameras have shown up the cause of faulty meshing in automatic transmissions, brake judder, the flap of timing chains, the bounce of valve springs and the reason for crown-to-crown entry of a starter motor pinion as it engages the flywheel. Slowed down 400 times, the deformation of motor car tyres as they speed over bumps has revealed possible shortcomings in tubeless tyres. Studied in slow motion, a motor-car suspension was shown to be insufficiently robust for the task of encountering continental pavé.

Most applications in the aircraft industry are still centred on problems of defence. High-speed cameras are being used every day to record the flame fronts from rocket motors and ramjet engines. Missiles carry special rotating prism cameras engineered to withstand the enormous G loads encountered in this type of work. The Wollensak Fastair camera works well even when subjected to 100G and is used on free flight missiles to record malfunctioning of control surfaces.

But most high-speed cameras at work in industry lead a less exciting life. Some are looking at production processes, and finding out, for instance, how a cigarette-making machine can be coaxed into producing more cigarettes per second. A manufacturer of boiled sweets found out why his acid drops stuck together as they left the moulding head. The necessary modification became obvious from the film, and the rejection rate was reduced by 15 per cent. Packing, wrapping, and capping machines, all of which normally operate at a speed far greater than can be perceived by the eye, have all proved good subjects, and methods of increasing their production rate have always become apparent from the slow motion record.

The actions of stamping presses have been analysed, and valuable information has been obtained of their performance. One job consisted of analysing the deflexion on the base of a heavy machine, and another of recording the air-blast ejection of parts from the die. The mechanism of grinding operations, and metal forming processes have also been fields in which high-speed cinematography has been of great benefit in the last few months. A measurement of shot peening speeds was obtained in only a few hours work with high-speed film camera after development engineers had been trying to find shot velocities using other instruments for several months.

Out of doors, the high-speed camera has shown what happens when railway trains hit hydraulic buffers, and why even Pacific class locomotives leave the rails when passing badly adjusted points. Films of exploding rock faces have revealed the speed of crack formation and have given valuable information to mining engineers. Working on a more mundane plane, the high-speed camera has been used to show why the grass so laboriously cut by a man pushing his lawn mower so rarely finds its way into the grass box provided.

These are but a few of the hundreds of new applications that are presented each day to the many groups throughout the country specializing in high-speed cinematography. It is a technique that is growing so fast that one manufacturer of automatic calculating machinery has invested in three separate high-speed cameras.

Although cameras which use film at 250 ft. a second, and take pictures at the rate of 16,000 pictures per second may sound fast enough, they are only at the bottom of the speed spectrum, as far as high-speed cameras are concerned. Film cameras are in daily use which take pictures at the fantastic speed of 40,000,000 every second; a single exposure can be taken with the duration of less than 1/1,000 millionth part of a second. Here indeed, is a branch of applied science that has reached its ultimate. It is possible to take pictures at such a rate that nothing moves fast enough to warrant such a taking speed. Even light itself, travelling at 186,000 miles per second has moved only a few inches during the exposure of a single picture.

(*Continued in page* 266)

Industrial Applications of High Speed Photography

(*Continued from page 265*)

DISCUSSION

The CHAIRMAN (Dr. W. E. HOARE) said that there was no need for him to say how amusing, well delivered and informative had been the address which had formed the last paper presented at the Annual Conference. For amateur photographers like himself, it was difficult to see how films could be exposed in the infinitesimally short periods of time that Mr. Hadland had indicated. Could he expand a little on the various methods used to obtain an exposure in these very short durations.

Mr. HADLAND said that a normal photographic shutter of the diaphragm type could open and close in about 1/2,000 second. With a focal plane shutter this could be reduced to 1/100,000 part of a second, at the cost of severe distortions due to one side of the film being exposed before the other. Limiting the exposure, by limiting the time during which the subject was illuminated, provided a means of making exposures in the order of one microsecond. This was usually done by illuminating the subject with a bright flash of light obtained by discharging a condenser charged to a high voltage through an inert gas. Using Kerr Cell shutters which made use of the polarization effect of nitrobenzine under severe electrical stress, it was possible to obtain exposures in the order of 10^{-9} seconds. This was an exceedingly short period of time, and could be represented dramatically as an analogy. If one day in this space age we were able to travel from London to California in one second, then in 10^{-9} second we would have only travelled 0.4 inches along this distance.

Investigations into the Wear of Punches and Dies

(*Continued from page 262*)

not being the amount of wear which both the manganese and chrome steel showed when used with rust-resisting sheet ?

Dr. CRASEMANN replied that the difference was not maintained after 100,000 cuts.

Fig. 6 demonstrated mainly, that it might be economical to cut deep-drawing-quality sheet steel with tools of manganese steel. But in cutting rust-resisting materials, the more expensive 15 per cent Cr. alloy tool steel was absolutely necessary.

Mr. A. E. HOBBIS (Austin Motor Co. Ltd.) asked what clearance Dr. Crasemann recommended on punch and die with various types of mild steel.

Dr. CRASEMANN replied that a clearance of 5 per cent of sheet thickness was recommended. There was a little difference with hardened steel. That had been the clearance which had been taken for the reported results. If thicker steels were cut, for example 10 mm. instead of 1 mm. a larger clearance, from 8 to 12 per cent of sheet thickness was preferred.

A SPEAKER asked whether consideration had been given to the heat-treatment of the manganese and chrome steels used in the investigation. Had hardness tests been made on the steels before performance and had the work-hardening effect of the two different types of steel during blanking been considered during the investigation ?

Dr. CRASEMANN said that the manganese steel had a hardness of 58 D.P.H. and the chrome steel a hardness of about 59 D.P.H. The hardnesses had been about, but not exactly, the same.

The same SPEAKER asked whether any test was made of the punch at the end of the run to discover the work hardening effect on the die and the punch at the end of the run.

Dr. CRASEMANN said that that had been observed. The investigations were continuing and the hardness of the tools had been measured after 10,000, 20,000 and so on, on to 100,000 cuts. With the micro-hardness tester it had been found that an increase from 59 D.P.H. to 61 or 62 D.P.H. was obtained by cutting transformer sheet with tools of chrome-alloyed steel.

Mr. WALL (Associated Automation) referred to the sketch in the paper indicating that the angle of crack formation had been found to be 7 deg. to 8 deg. He assumed that that applied to steel, but that the angle would be the same for aluminium alloys.

Mercury-arc Converter for Steel Mill

A MERCURY-ARC rectifier/inverter equipment supplying a 4,000-h.p. reversing billet mill drive has recently been commissioned by Associated Electrical Industries Ltd. at the Stocksbridge Works of Samuel Fox and Co. Ltd.

The equipment is made up of pumpless steel-tank mercury-arc rectifier/inverters, with an R.M.S. rating of 3,200 kW. and a voltage range of 0-900 volts, and is situated, with its associated grid-control cubicle equipment, on the gallery in the motor room. The 12-phase, 66-kV. rectifier transformer is housed in a separate sub-station.

A closed-loop system of speed control is included in the equipment.

Automatic Presswork on MULTI-SLIDE MACHINES

By JOHN H. HAYES, A.M.I.Mech.E., A.M.I.Prod.E.*

(A paper presented to the Midland Branch of the Institute of Sheet Metal Engineering)

IN the constant struggle for lower costs and higher quality, the production engineer is ever in search of better methods. This applies in every branch of industry and press work is no exception.

Since the earliest days of toolmaking much endeavour has been directed to make the process of producing parts by chipless methods in presses more and more automatic. Press tools which have become accepted engineering units are really quite intricate machines. A progression die with many stages supplied with strip material by an automatic feed is a much more advanced form of mechanism than the nonchalance with which it is treated through familiarity would imply.

The advance of press-tool design necessitated simultaneous advance in the machines in which these tools were to be employed. Today an impressive array of machines and approaches is available to make automatic presswork a reality.

Automatic presswork is a vast subject and a broad summing up of machines employed for this process would include :—

(1) Conventional presses with automatic feeds ;

(2) Several presses tied together with devices transferring parts from press to press ;

(3) Transfer presses proper ;

(4) Dieing machines, and

(5) Four-slide strip forming machines.

The purpose of this article is to discuss the last-named only and concerns itself with three major aspects :—

(I) Design, general function, construction and safety ;

(II) Economy ;

(III) Special tooling.

I—Design, General Function, Construction, Safety

Basically the multi-slide machine is a power press turned through 90 deg. so as to lie on its back. That is to say, the strip travels through the machine on edge (Fig. 1). In a typical machine the strip leaves an automatic horizontal stock reel with mercury switch control and enters a stock straightener. This is a multi-roll straightening device designed for removing coil set and readily adjustable for material thicknesses and widths within

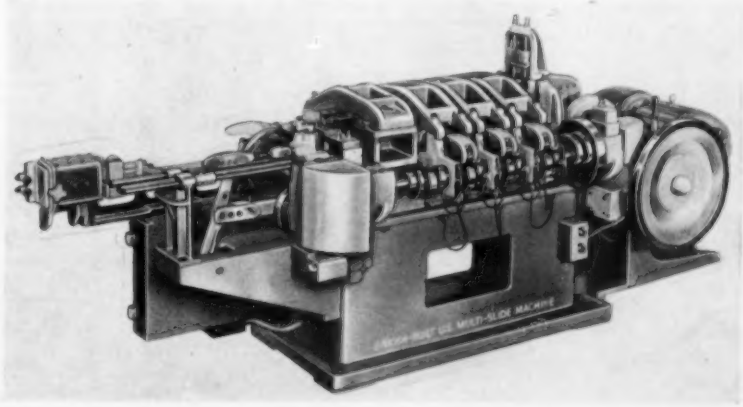


Fig. 1.—Front view of No. 35 U.S. Multi-Slide

(Courtesy of Rockwell Machine Tool Co. Ltd.)

* Rockwell Machine Tool Co. Ltd.

the machine's capacity range. The straightener is of the hinged type to facilitate loading.

From the straightener the strip enters an automatic slide feed. This feed is of the positive gripper type and its most important feature is the fact that the feed block which carries the material from pitch to pitch runs between positive stops thereby eliminating overfeed. The inner stop is fitted to a main casting while the outer stop is fitted to a separate bar so that temperature rises caused by the feed block reciprocating on its guide bars do not influence pitch setting accuracy. Close accuracy, so essential for precise progressive die work, can be achieved with this feed unit. The feed is readily adjustable to cater for all pitches within the machine's capacity and for various thicknesses of material.

From the feed the material enters a stock check. This is a cam-actuated " clamp " which serves to trap the material as soon as the feed stroke is complete, thus preventing the material backing up during the return stroke of the feed. The check releases only during the forward stroke of the feed, or, when pilots are used, just before the pilots enter.

Having passed the stock check the material enters the actual pressing area. The bed of the machine is designed for up to four die heads or ram stations, depending on the size of the machine, the individual rams being cam-driven short-stroke units with pitman adjustment; they can be individually moved in relation to one another. Due to the symmetrical construction of the machine, the die heads can be mounted so as to operate from front to back or from back to front. This is an important feature as it permits tools to be arranged so that any burrs produced are in the less objectionable direction. Special dovetailed die sets are used facilitating tool setting and these are provided in a number of standard lengths. The pressing motion of the die heads can be individually timed within certain limits to spread the load on the cam shaft. While the material travels through the die heads, these perform all the piercing, cropping, preforming, pre-bending and other operations which may arise, until a complete " developed " blank leaves the last die head. This blank is still attached to the end of the strip and frequently represents the component in that form in which previously all thought of further automatic operation ceased. There the part would normally be ejected from the conventional press or dieing machine and subsequently formed in a second operation press. In the Multi-Slide machine, however, the part at the end of the strip is fed further until it reaches the " heart " of the machine *i.e.* the four-slide forming station.

Viewing the machine from the top (Fig. 2) the system of cam-shafts surrounding the machine can be seen with the plan view of a die head on the left. To the right of the die head can be seen an aperture, through which finished parts generally leave the machine. Around the aperture are four slides; these are the actual forming slides which serve to bend the component around a vertical form post (not shown) or without a form post if the geometric configuration of the part does not permit the use of one.

Fig. 1 shows a cast bracket on the right of the machine which carries the vertical form post and the stripping mechanism. (The latter can also be used as a transfer mechanism for vertical transfer when more than one hit is required to complete the forming.) Thus any blank presented to the form post will allow convenient forming by the four forming slides (Fig. 2). All these can be timed and positioned individually. The length of stroke and mode of motion are governed by cam design

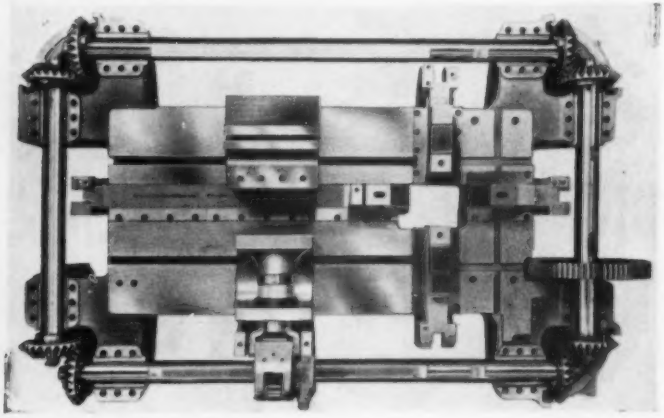


Fig. 2.—Plan view of bed

(Courtesy of Rockwell Machine Tool Co. Ltd.)

and the standard cams supplied with the machine are adequate for many normal applications although special cams may be required to suit unusual conditions. Split slides can also be fitted as these may be necessary for lock-seaming work and other more complicated tasks. The cams are split and mounted on carrier discs so as to facilitate easy removal and timing. Timing is further facilitated by the carrier discs having engraved divisions. Cams and rollers are hardened and ground to ensure smooth running and the slides run in hardened and ground ways to reduce wear and facilitate replacement. All such moving parts are made to ultra-close limits to allow interchangeability and precision alignment. It is apparent that such close accuracy is essential as there is no possibility of using pillar die sets in the forming stations (although small sub-tools can sometimes be employed), and forming tool mating is controlled largely by the slide-ways.

Between the forming station and the last die head is a cut-off slide which serves to sever the developed blank from the parent strip. The question which arises here is how the severed blank is supported during the brief time interval between cut-off and initial contact of one of the forming slides (generally the front slide). This is achieved where possible by a spring-loaded plunger, usually in the front slide preceding the actual form tool and trapping the blank against the form post during cut-off. Alternatively, if this method proves unsuitable due to part configuration or weight, a so-called positive blankholder is employed. This is a cam-controlled plunger operating independently from, but timed to work in unison with, the front slide. After completion of the forming operation the component is stripped vertically by the stripper slide described earlier. It may also be transferred vertically to a lower level on the form post for re-striking or forming in a lower level. This vertical transfer can take place up to three times depending on component height.

Air jet timing devices can be fitted to facilitate stripping if necessary and variable-speed drive allows products to be manufactured at optimum rates.

Many auxiliary mechanisms can be fitted and these will be discussed later under the tooling section as they are more closely related to this aspect.

Due to the high costs of progression dies, machine safety is of the utmost importance and is catered for by the incorporation of limit switch monitoring devices. A master switch is actuated at each revolution of the machine and will stop the machine if not supplied with "all clear" signals from wherever monitoring switches are fitted. These can be applied to pitch accuracy (this being achieved by a probe contacting the end of the strip as it emerges from the dies prior to cut-off), to sensing pierced holes (unpierced holes indiating punch breakage and arresting machine), to end of strip and to buckling (by incorporating suitably designed "traps" ensuring that material will buckle at a given point if prevented from normal progress). These monitors can only be effective, however, if very efficient and rapid braking is catered for. For this reason a high-performance electro-magnetic brake is fitted. This brake acts directly on the flywheel and arrests the machine even at top speed in less than half a camshaft revolution. Central lubrication is incorporated, further assisting safe running of the machine.

Having described at some length the general construction of the machine it will now be possible to look into some of the economy aspects of Multi-Slide presswork.

II—Economy

There are many characteristics whereby extensive savings can be effected with this type of machine.

The principle of carrying the blank at the end rather than in a webbing of strip frequently allows manufacture of the component from a strip width no wider than the actual pressings. An important point here is, of course, the availability of strip to width limits close enough to permit this. Such limits cannot always be procured but even where cropping has to be carried out to obtain accurate width, less metal is scrapped than in carrying the blank in the strip. Again, cutting the blank from the end of the strip is generally the least material-wasting way of production in terms of stock lost between blanks.

The vastly greater rigidity of the machine as compared with conventional presses also materially contributes to savings. The combination of short stroke and condensed tie bar supported die space results in greatly increased die life, in fact, users claim lengths of runs generally associated only with tungsten-carbide tooling. Die life is further increased by the horizontal disposition of the die stations permitting greater control over punch entry into the die. Due to this rigidity added to the less accident-prone tooling, Multi-Slides can often be run at much higher speeds than conventional progression die presses. On the smaller machine speeds up to 160 strokes per minute are not uncommon, and on the larger machine, where sometimes 100 tons and more pressures are involved 80 to 100 strokes per minute can frequently be obtained. Such speeds are also due to the monitoring devices and rapid braking possible in case of jamming.

On the subject of tool cost it can generally be assumed that the die or ram station tools will require similar expenditure as that encountered

with progression dies, although some of the auxiliary mechanisms which will be discussed later may even here effect tool cost reductions. In the forming stations, however, real tool cost savings can be achieved as will become obvious if comparisons are drawn with the type of complicated progression die sometimes employed to produce multi-bend or "wrapped" components. Where the progression die needs side cam motions, and the associated difficulties and expenditure, the Multi-Slide machine incorporates these motions as part of its basic design, reducing the tool making aspect to the provision of punch and former parts only. Generally, therefore, once the peculiarities of the Multi-Slide technique have been mastered, tools will cost less than progression dies. There are also components where the overall length may vary while basic characteristics of the part stay constant. In these cases the possibility of varying the position of the die station or stations relative to the forming station allows employment of the same tools for a number of parts.

Due to the breakdown of tooling into various die stations it is sometimes also possible to correct out tool errors or the phenomenon known as material growth (caused by cropping on soft and thick materials). This feature also reduces tool costs.

When considering cost reductions it must not be forgotten that in some instances the Multi-Slide machine can be employed to press several components simultaneously without extra stock between the parts being required. The machine can also on certain applications be used to assemble two components and in special cases for tapping.

Toolsetting

The main objection frequently raised against the Multi-Slide machine when comparing it with other methods of automatic pressing is the time required for setting the machine. In close association with this objection usually follows the question: What constitutes a minimum economical run?

It cannot be denied that toolsetting on a Multi-Slide machine does require more time than setting a conventional press. Setting times of established tool sets may vary from three to eight hours. This, of course, is rapidly offset once the machine is in production.

Taking the extreme case of a component lending itself to conventional progression die practice readily, as well as being suitable for the Multi-Slide, and assuming the component can be produced complete in one stroke fitted to a conventional, say, 25-ton press, running at 100 strokes per minute, such a tool would require a setting time, including setting of an automatic feed, of two hours. That is to say that the press would produce $6{,}000 \times 6 = 36{,}000$ pieces in the first eight-hour day. Assuming a set-up time of five hours for the Multi-Slide and a speed of 150 strokes per minute, the Multi-Slide would admittedly produce only 27,000 pieces in the first eight-hour day. On a two-day basis, the press would produce $36{,}000 + 48{,}000 = 84{,}000$ pieces and the Multi-Slide $27{,}000 + 72{,}000 = 99{,}000$ pieces. Thus, even on a short run of only two days the Multi-Slide shows an advantage. Considering a week's run, however, the Multi-Slide will produce $(27{,}000 + (4 \times 72{,}000)) = 315{,}000$ pieces as against $(36{,}000 + (4 \times 48{,}000)) = 228{,}000$ pieces on the press. Add to this the cost reduction achieved through simplified tooling, increased die life and lower maintenance time and even in this unusual case the Multi-Slide is a sound proposition.

As this is an unlikely situation, consider a more typical case where, when conventional methods are employed, a progressive die in a crank press would produce the developed blank and a second-operation press would be used to carry out the final forming. The following picture now presents itself:—

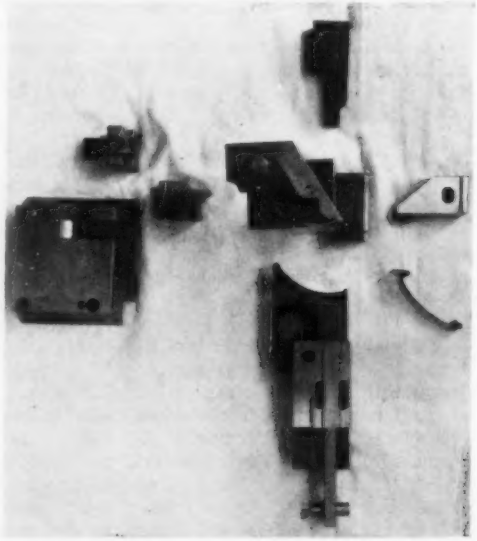


Fig. 3.—Tooling for spring clip

(Courtesy of Rockwell Machine Tool Co. Ltd.)

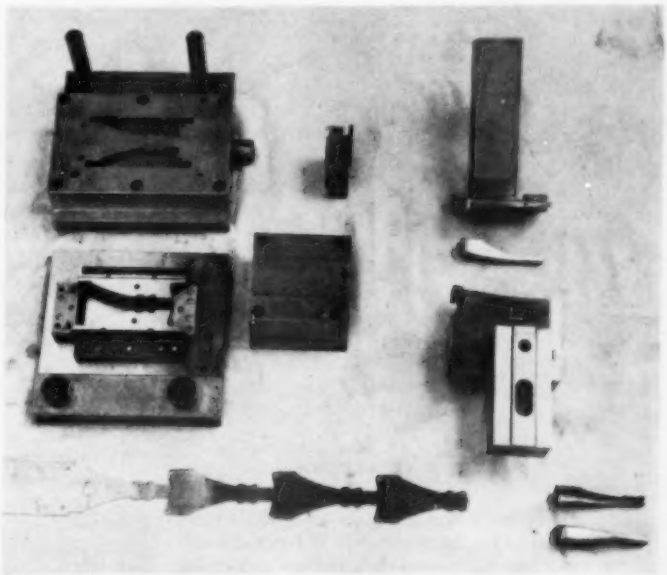


Fig. 4.—Tooling for windscreen-wiper part

(Courtesy of S.W.F. Bietigheim and Alltools Ltd.)

Set-up for progression die ..	1 hour.
Set-up time for forming die (including fitting dial feed)	1 hour.
Output from progression die	6,000 per hour.
Output from 2nd operation die (assuming dial feed loading)	2,000 per hour.
One operator can produce in 38 hours (40-hour week less setting time)—	
9½ × 6,000 blanks ..	57,000
28½ × 2,000 forms	57,000
	114,000 parts only

One operator on the Multi-Slide, however, still produces 315,000 parts.

In many instances where Multi-Slide machines are now employed they have replaced methods requiring far more than two previous operations and the implications in terms of savings are obvious.

It should also be borne in mind that one operator can, and in many plants does, look after more than one Multi-Slide machine. The Multi-Slide will score wherever second operations are necessary without it. There exists an actual case where a user who could employ his Multi-Slide for only 25 per cent of its actual output capacity claims that the machine still paid for itself in 18 months.

There are, however, few manufacturers who would be prepared to have a piece of equipment standing idle for 75 per cent of its time. Thus, in instances where typical Multi-Slide parts can only be found to partly load the machine, there is no reason why the machine should not be employed on more conventional work which does not have the intricate forms which would make it ideal for Multi-Slide production. Some of the many advantages enumerated earlier would still apply even then.

III—Tooling

A consideration of Multi-Slide tooling involves the discussion of auxiliary devices mentioned earlier. Rather than describe these as a separate section, they will be covered as and when they arise in conjunction with the examples.

Fig. 3 shows a tool layout for the spring clip also shown in the illustration. This is a very simple toolset not involving any die stations and, therefore, ideal for showing the action of the forming slides only. The tools are laid out in plan view as seen from underneath. Even a simple set-up like this incurs certain auxiliaries and has its difficulties. The auxiliaries used here are : a rear cut-off slide, because the cut-off is shaped, and a positive blank-holder (the ram slide in the front tool with the two drive spigots) which serves to hold the part after cut-off and before forming commences. This device is cam-operated by its own cam and entirely independent from the motion of the front slide.

The main difficulty here lies in the fact that the material is spring steel and very considerable over-bending is necessary to achieve the correct work-piece contour. The action sequence is : the front

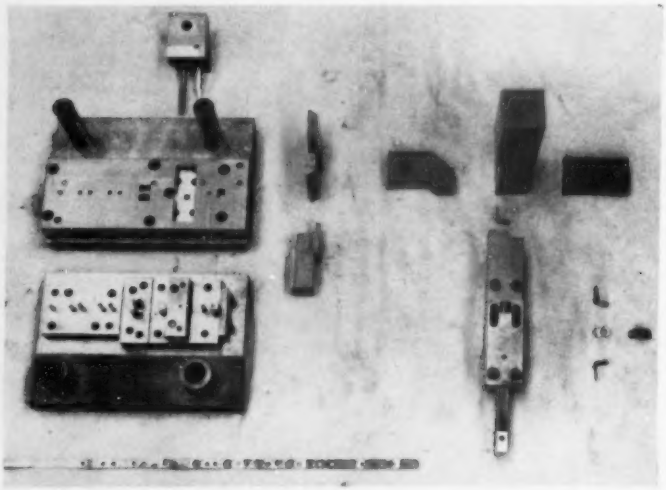


Fig. 5 (left).—Tooling for electrical part

(Courtesy of Joseph Lucas Ltd. and Alltools Ltd.)

slide comes in and makes the main bend, right-hand and left-hand slides enter to produce the bent loops at the ends and the rear slide enters to secure the smaller loop. The radii for the various bends have to be established empirically to allow for spring-back. Material : 0.0128-in. spring steel. Output : 120 per min.

Fig. 4 shows a windscreen-wiper part which is interesting on account of its complicated shape and the considerable amount of material which has to be cropped off in the die station to obtain the developed blank, the tonnage required to do this being approximately 20. The " V "-shaped recesses in the die serve to trap the croppings and to prevent their pulling back or toppling in the die. A shaped cut-off is used here also again requiring a rear cut-off slide. The final form employs one toolside only and the vertical form post carries the male form of the profile. The forming die has a spring-loaded, shaped insert which serves as a draw pad

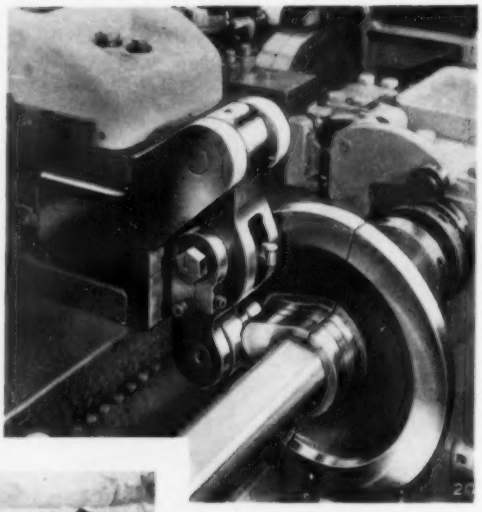


Fig. 6 (below).—Auxiliary rear slide

(Courtesy of Rockwell Machine Tool Co. Ltd.)

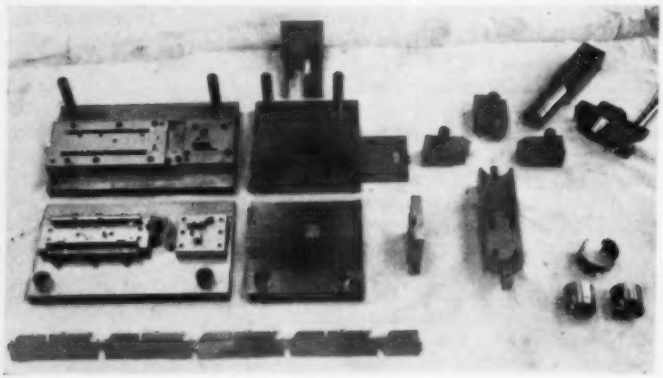


Fig. 7. (left)—Tooling for vacuum cleaner part

(Courtesy of Hoover Ltd. and Alltools Ltd.)

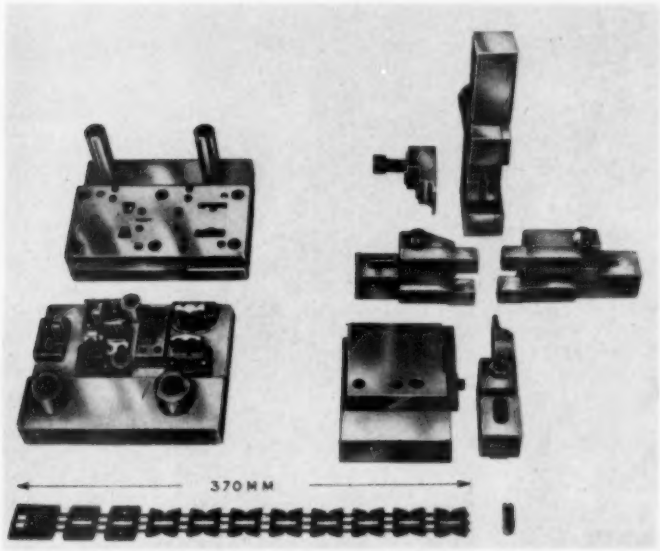


Fig. 8 (left).—Tooling for windscreen wiper part

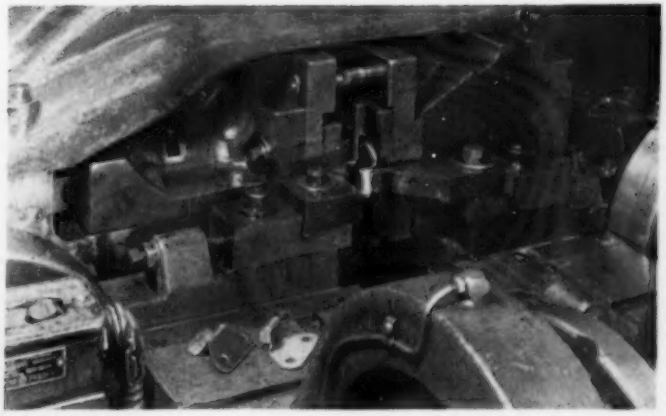
(Courtesy of Magnatex Ltd.)

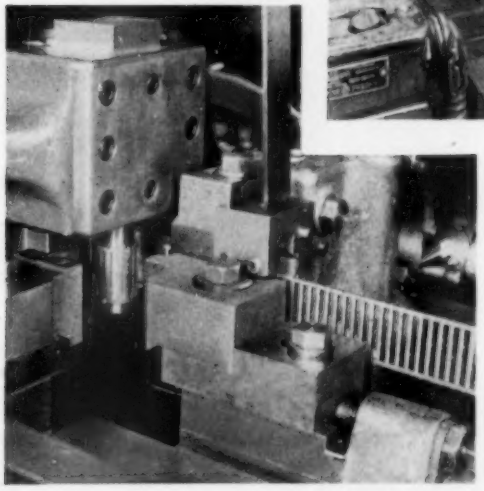
Fig. 10 (below).—Tooling for lock part

(Courtesy of U.S. Tool Co. Inc.)

Fig. 9 (below).—Tooling for bearing cage

(Courtesy of U.S. Tool Co. Inc.)





and ejector. Note the well-defined radii and clean contours. Material is 0.048-in. thick mild steel and output 90 pieces per minute.

This electrical component (Fig. 5) makes use of a number of auxiliary devices and is more complicated than would appear at a first glance. The die section includes two " V " shaped cut-outs which pre-crop the parting line chamfer so that a straight cut-off can be employed. In this case, therefore, a front cut-off slide is used. For this component it was necessary to employ a rear auxiliary slide (*see* Fig. 6). The function of this auxiliary attachment is to provide a motion within the die opposed in direction to that of the die head. It is an independent slide operated by its own cam with stroke

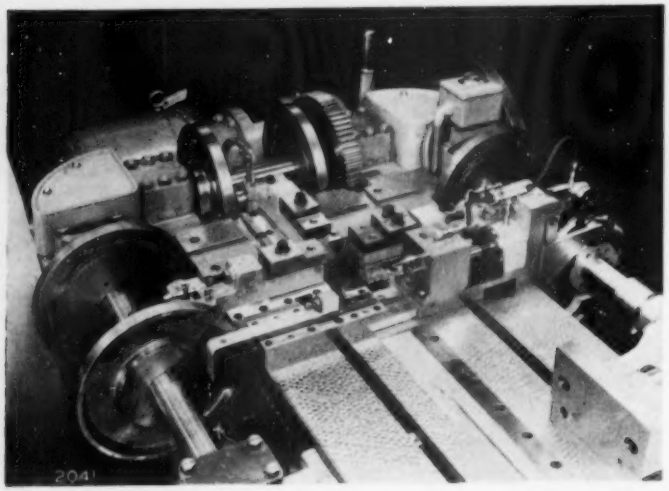
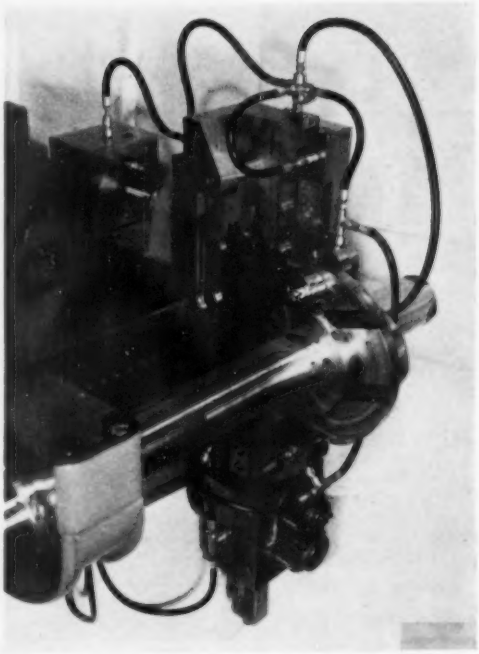


Fig. 11a (left) and 11b (below).—Tapping head

(Courtesy U.S. of Tool Co. Inc.)

and timing to suit conditions. This attachment is used frequently where tabs or lugs have to be bent in the die station where semi-piercing is carried out, etc. The main idea is to provide a " double action " so that lifter pins are obviated and the stock remains undistorted. Since both the punch and the die move, the material passes through the tools in an absolutely straight line and difficulties normally encountered through deflections, buckling and friction are avoided. The punches actuated by the rear auxiliary slide in this case are shown at the top of the picture. They are mounted in their holder block which in turn is bolted to the cam operated slide. The punches enter the largest round and the square hole in the die and produce the large semi-pierce tapping extrusion and the small bent lug in the part. Note also the small indented ridges which serve to strengthen the corner of the part after bending. The central forming station is rather simpler here, although again employing the positive blankholder in the front slide. Note that the plunger of this slide here takes the shape of the extruded hole to give maximum positive location. The sequence of operations is as follows : the front slide makes right-angle bend after cut-off. The left-hand slide secures the bend. The right-hand slide serves only for backing up the form post. Finished parts can be seen on the right. Material is 0.030-in. thick brass ; output is 120 pieces per minute.



Tooling for a dovetail-jointed wrapped part is shown in Fig. 7. The die stations are in two sections the first of which carries out the cutting operations while the second bends the four 90 deg. lugs. Note again the " V " traps for the cropping operations preventing return of croppings. Here also the rear auxiliary slide is employed and its tools are shown at the top of the photograph. The strip stays still while this slide makes the lugs without causing any distortion whatsoever. The auxiliary slide station also produces the step in the component in the most convenient manner. The developed blank is severed from the parent strip by a dovetail-shaped cut-off which can be clearly seen on the " open " component on the

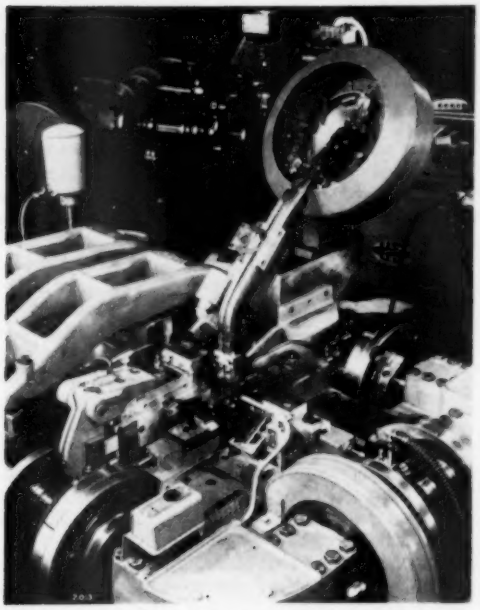


Fig. 12.—Set-up showing automatic assembly

(Courtesy of U.S. Tool Co. Inc.)

right. In the forming station, again observe the positive blankholder in the front slide. The sequence of operations here is : Form " U " with front slide, form circle with left- and right-hand slides, secure dovetail joint with rear slide. The rear-slide tool has a spring-loaded section so that one-half of the joint is held securely against the formpost by the sprung part before the other half of the joint is pressed home by the unsprung part. The part is finally stripped off the form post by the stripper slide actuating the stripper ring shown obliquely parallel together with the form post in the illustration.

This is a difficult part due to the ridge causing two diameters, the joint and the very much reduced width at one point of the circumference. It is made from 0.048-in. thick aluminium alloy and will run at 80 pieces per minute.

Fig. 8 shows the tooling for a windscreen wiper part made from stainless steel. A rear cut-off slide is again employed because when cutting off, the centre portion of the three connecting lugs in the strip is blanked, therefore requiring a die. The forming station is different from previous examples in that the form post is used as a die. The sequence of operations is as follows : The front slide forms the blank into a " U " shape using the form post as the forming die, the left-hand and right-hand slides close the " ears " of the part. The rear slide is idle, but a spring-loaded ejector pushes the work-piece out to fall clear as soon as the front and side slides retract. Material is 0.026-in. thick stainless steel and output is 120 pieces per minute.

Fig. 9 shows the forming station in the production of a needle bearing cage. An interesting modification employed here is that the feed mechanism and die make a predetermined number of strokes to one cycle of the forming position. The number of strokes depends on the number of windows in the finished piece.

Fig. 10 shows the outgoing side of a set-up not employing a form post due to the two closing lugs on the part. With the aid of a special toggle head adequate pressure (up to 100 tons on the large machine) can be made available to coin countersinking indentations for screws on this and similar parts.

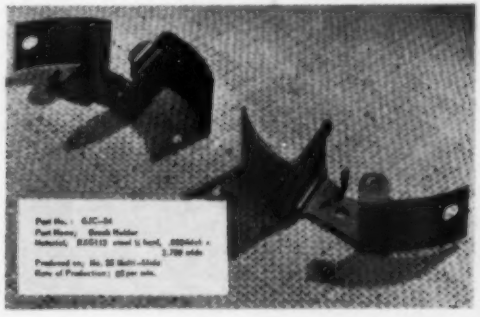
Fig. 11 shows the tapping unit mounted on an otherwise stripped machine. This unit is entirely mechanically operated, both feed and rotation

Fig. 13.—Contact bracket. Material: CRS 0·062 in. thick by 2⅛ in. wide. Produced on No. 35 U.S. Multi-Slide, two at a time at 80 strokes per min. i.e. *160 components per min.*

(Courtesy of Rockwell Machine Tool Co. Ltd.)

Fig. 14.—Brush holder. Material: RXG113 steel, ¼ hard, 0.05 in. thick by 3·780 in. wide. Produced on No. 35 Multi-Slide at a rate of 80 per min.

(Courtesy of Rockwell Machine Tool Co. Ltd.



being derived from cams. This illustration also shows a split front slide sometimes necessary for difficult forms and seams.

Fig. 12 shows a set-up where nuts are hopper-fed and assembled to a pressed nut cage. This example shows the versatility of the process and its adaptability to quite individual requirements.

Fig. 13 is noteworthy for the fact that two pieces are made simultaneously. Also note the heavy embossing to strengthen the corners.

A brush holder (Fig. 14) shows the versatility of the machine to advantage. This part has bends in many directions, much embossing and a semi-pierced hole for tapping. A great number of operations were saved by employing the Multi-Slide.

Conclusion

While the problems which may be encountered due to grain direction, length of run and tool change-over times may be disadvantages of Multi-Slide practice, the savings possible, due to reduction in tool cost, reduction of labour costs, increased versatility and adaptability will make this method an economical proposition in most instances where the right type of component exists. Also, because many pieces cannot be made completely in any other way, the Multi-Slide approach will often provide the solution where other methods fail.

DISCUSSION

Stroke Limitations

Mr. ELKINGTON (Midland Branch Chairman) said that he was interested to see some of the pressings being done, but it did appear that there were limitations as to stroke. Providing the job was within the cam movement of the machine it appeared that there was great scope in its application generally.

Mr. HAYES said that it was possible to fit special cams and so obtain a little more scope, but by and large it was necessary to work within the capacity of the machine.

Mr. ELKINGTON asked whether the cam restricted the total load very much.

Mr. HAYES, replying, said it was not really the cams that restricted the load but the design of the machine. However, for smooth operation it was possible to work safely within the machine's designed capacity.

Answering a further question from Mr. ELKINGTON, Mr. HAYES said that a typical machine, the 28, was capable of carrying stock up to 1½-in. wide and would cost roughly £3,500—plus auxiliaries and tooling if required. The largest machine, the 35, had a basic price of £6,500. Although these prices might seem high compared with conventional presses, with adequate production requirements the cost could very soon be reclaimed.

Mr. BUTTERFIELD (Fisher and Ludlow Ltd.) said that the machines shown in the film were running under exemplary conditions of cleanliness; it occurred to him that the open slides used would have a limited effective life which was a bad thing as the tools were unguided by any other means.

Mr. HAYES said that a user would be unlikely to get pressing scrap or slugs anywhere near the slides because they were chuted away. As far as general dirt in the factory was concerned, automatic lubrication was provided and the slides were hardened and ground. He quoted an instance of a user employing pre-war American-built machines where the slideways had not been taken up yet.

Cam Design

A SPEAKER (from Japan) said he would like to ask about the shafts surrounding the machine. These incorporated cams. Were they standard or designed for each component ?

Mr. HAYES said that the cams provided with the machine were standard cams giving a certain stroke and mode of motion. They were hardened and ground to given dimensions which were considered adequate for most purposes. For special applications where other modes of movement or strokes were required, special cams could be provided.

Mr. BAKER (Fisher and Ludlow Ltd.) said that it appeared that 16 gauge was the heaviest material being used; was that the maximum ?

Mr. HAYES replied that the large machine was able to handle $\frac{3}{32}$-in. material, but on occasions thicker materials were used. Actual thickness itself was not the deciding factor; it depended on how much cutting was done.

Strip Lubrication

Mr. HOBBIS (Austin Motor Co. Ltd.) asked Mr. Hayes to give figures for production he would expect before the tools had to be ground and also what type of lubrication he would use on strip.

Mr. HAYES said that one customer who employed a number of multi-slide presses had continuous runs of three and four weeks with the machine running 40 to 50 hours a week and not one of them at less than 100 strokes a minute; this had prompted him to say that some runs compared with tungsten-carbide tooling. This customer felt that the rigidity in the machine accounted for these long runs because with similar tools in open presses shorter runs were obtained. As far as strip lubrication was concerned, any suitable lubricant could be used; it would not interfere with the machine as the one slide that was underneath the tools was well shielded.

Mr. WRIGHT (Renold Chains Ltd.) asked what were the limits obtained in the production of bushings.

Mr. HAYES said that in America bushings had been produced completely finished to the limits they required which, he thought, were of the order of 0.0005 in. Machines had been designed to rotate the parts through 90 deg. and re-strike them again if required in the new position. The machine was basically simple, the secret was in the tooling.

Capacity of Slides

Mr. SALMON (Austin Motor Co. Ltd.) asked what was the tonnage capacity of each slide on the largest machine.

Mr. HAYES replied that it was about 20 tons on each die head. He would not suggest using 20 tons on each die head simultaneously, but it was possible, due to the design of the machine, to split the loading up to some extent so that the full 80 tons on the camshaft was obtained. The tonnage on the forming slides was much lower, *i.e.*, about 8 to 10 tons. The danger of quoting tonnages especially on the forming slide was that it was not only a matter of " how much " but " where " it was applied.

Mr. MONOGHAN (Fisher and Ludlow Ltd.) asked whether there was a particular sequence of operations or could any sequence be used.

Mr. HAYES said the sequence of operations as far as die stations were concerned would be very similar to those employed in normal progressive dies, with the exception that it was necessary to bear in mind that there was the auxiliary slide feature making it possible to do certain forming operations in a simplified manner in the die stations.

Subsequently, in the forming, it was desirable to design the component in line with the machine's characteristics. This was quite a serious aspect. Press components ought to be designed in line with the plant available. In other words, while it was often possible to obtain complete pressings—where hitherto difficult second and third operations on a component were standard practice—using the multi-slide without modifying the part, it might sometimes be necessary to re-design the component to some extent to make full use of the machine. This surely would be worth while to obtain production of intricate parts in one " hit."

Guarding

Mr. HOBBIS (Austin Motor Co. Ltd.) asked about guarding the machine.

Mr. HAYES said that one user who had six machines now and who was very guard-conscious had completely enclosed the machine. This was not done with one single guard, but with a series of guards, the advantage being that if it was required to adjust, say, the feed, it was not necessary to remove all the guarding. This company were now considering interlocking the guards electrically.

Mr. ORDISH (George Salter and Co. Ltd.) asked to what degree of accuracy would the stock straightener straighten edge bow on strip, and to what width and thickness of strip.

Mr. HAYES said that a two-way straightener was not often used. A normal roller straightener was adequate for flattening the strip to remove coil set, but edgewise camber could not easily be removed if the material was wide and thin. It was preferable to have straight strip in the first place.

Mr. ORDISH (George Salter and Co. Ltd.) said that edge-camber was one of the biggest difficulties in using multi-slide machines.

Mr. HAYES replied that there were many ways of overcoming this problem but not necessarily by straightening. With a component where side cropping takes place, *i.e.*, where the part was not of the parent width, this problem was not quite so serious. On the other hand, if an attempt was being made to work with parent width strip and not reduce this width—in other words, the width or length of the component was equal to the parent width of strip—then an intricate method was required to overcome this. There was always a tendency with edge camber to open out the die guide strips. Then the material moved about with considerable clearance, which was not desirable. The next thing was to try a spring-loaded guide strip which in a short time showed grooves worn in by the strip. Mr. Hayes said that the solution was to use a mechanically operated guide strip, actuated by the motion of the top tool; in other words, the guide strip pushed against the material only when the tool was shutting. When the tools opened, *i.e.*, as soon as the feed was started, the guide strip released the strip and in this way side pressure was put on the strip only when it was needed. A small toggle lever operated by the top tool imparted the motion to the guide strip.

It should be emphasized that the difficulties were in feeding, not forming. Feeding was by " pushing " and not as in a double roll feed where the metal was controlled at both ends. In pushing thin material into the die it had to be guided completely, and guides could be made which would completely shroud the strip except for a slot on each side. One one side there was a pad on which the metal was pressed when feeding; on the other side was a finger that pressed against the pad. If the slot was made narrower than the material, the strip was between a sandwich of steel plates in complete control. As far as forming was concerned, thicknesses as low as 0.005 in. had been processed. In one application a radio-valve anode complete with lock-seam was produced from material of this thickness.

(*Continued in page* 278)

Automatic Presswork on Multi-Slide Machines

(*Continued from page 277*)

Handling Scrap

Mr. DUGGETT (Fisher and Ludlow Ltd.) asked how the scrap was handled.

Mr. HAYES said that the forming operation generally produced no scrap; although there might be a cut-off slug. With a straight cut-off there was no slug at all and the part was formed so that there was scrap only in the earlier stages in the die heads. The scrap came out of the machine horizontally. In practice, the material did not build up in the horizontal holes and left the machine easily via a chute. The same applied on the cutting-off stage when slugs were produced.

Mr. NEWEY (Fisher and Ludlow Ltd.) asked what was the greatest size blank that could be used in the machine.

Mr. HAYES replied that the feed was very large, *viz.*, on the small machine 8-in. and the large machine 13-in. However, although the machine was built to feed such a length it did not mean that it was necessarily possible to wrap all the strip length round the form post, because the tail could swing out and interfere with the slides. The limiting factor on the actual blank size was the width. The length depended on the particular job and how the tools could be arranged. One job used a 10-in. long blank and came out very well indeed. This component was a large clip, the strip being about 1½-in. wide—and it was produced at the rate of about 70 a minute. In this case conveyors were introduced to take the components away and drop them into stillages because there was not enough room in the machine base for this high volume of production.

Mr. BUTTERFIELD (Fisher and Ludlow Ltd.) asked whether the form post was supported.

Mr. HAYES replied that the form post was generally not supported; it was virtually a stub arbor held in a clamp. If the component shape permitted this one or several of the slides could be used for supporting the form post. This was one of the limiting factors of the machine. If the formed post had little strength it could sometimes be supported from underneath using a retractable mechanism. Quite often " wrapped " forms, such as small ferrules, could be produced without any internal support.

Mr. MONOGHAN (Fisher and Ludlow Ltd.) asked whether it was possible to re-load a machine while it was still running, or did the mechanism automatically stop the machine.

Mr. HAYES said that one limit switch monitor system was incorporated as standard on all machines and the function of this was to stop the machine in the event of a short feed. There were actually two limit switches, one being cam-operated the other actuated by the end of the strip and the two were timed to work together. One was normally closed and the other normally open. These limit switches kept the machine going; when one failed the other stopped the machine. Other limit switch mechanisms could easily be added if required, *e.g.*, to stop the machine on reaching the end of the coil.

Mr. ELKINGTON asked whether it was possible to do shaving operations on the machine.

Mr. HAYES said that shaving was not one of the functions of the machine, although it could possibly be done in the die stations.

Mr. PAXTON (Renold Chains Ltd.) asked what accuracy could be guaranteed with the gripper feed and was it controlled by the rate of speed of any given component.

Mr. HAYES replied that the feed was accurate to ±0.001-in., although the speed would have some effect. It was easier to hold short pitches accurately at high rates rather than long pitches. Although if pilots were used on thin strip they only proved that the feed was right, it was advantageous to pilot when many stages were being used. In this case the stock check was released momentarily while the pilots entered; control over the material was, therefore, not lost.

Mr. Hayes, continuing, said that the feed was simple. It was a gripper feed using a toggle oscillating about a point. This toggle pressed the metal against a hardened pad on the forward stroke, releasing it on the return stroke. Feed accuracy was governed by the fixed stops.

SYMPOSIUM ON WIDE STRIP

The Iron and Steel Institute is devoting technical sessions at its Annual General Meeting this year to a symposium on wide strip production.

The scope of the symposium is wide, covering all aspects of strip production from steelmaking to manufactured goods. The opening session will review the future requirements of the tinplate and vehicle industries, the major users of wide strip. This will be followed by a session devoted to steelmaking practice. Strip rolling is dealt with in the third session. The fourth session is a mixed bag, and the final session deals with coatings.

The symposium starts at the Royal Commonwealth Society, Northumberland Avenue, London, W.C.1, on the afternoon of Tuesday, May 3, 1960. The subsequent sessions, on May 4 and 5, will be held in the Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1.

The effect of MILL SPRING ON GAUGE and the ROLLING OF TAPERS

By the late C. W. STARLING, B.Eng., A.M.I.Mech.E.*

IT is well known by anyone connected with rolling that when material enters the rolls the mill springs and the outgoing gauge is greater than the initial roll-gap setting. It is essential that the magnitude of this discrepancy is known for any particular mill and in practice the rollerman finds by experience the initial settings required to give the correct finished gauge. This setting is influenced by the rolling load, which in turn varies with width of material, ingoing thickness, hardness, temperature, coefficient of friction and other lesser quantities.

Mill Spring can be defined as the difference between the initial roll gap and the actual rolled gauge. If S is the gap between the rolls before the entry of the bar and h is the gauge of the rolled bar, the mill spring will be $(h - S)$. This will still apply if the rolls are in contact before the entry of the bar and even if they are forced together before the entry of the bar. If the rolls are just touching before entry, S will be zero and the mill spring will be h. If the rolls are forced together under a pre-load, then S will be the distance moved by the screws after the rolls contact each other and will be negative. For example, if the screws are run down 0.020 in. after the rolls make contact, S will be $-$ 0.020 in., then the mill spring $= (h - S) = h - (-$ 0.020 in.$) = (h +$ 0.020 in.).

The Mill Spring/Load Curve

Mill spring is due to elastic deformation of all the components making up the rolling-mill housing and the rolls and can be estimated from the geometry of the mill. When the bar enters the rolls there is immediate flattening of the rolls under the high pressure at the point of contact. In the case of a 4-high mill, the load is transferred through the work roll to the back-up roll and there will be flattening at the line of contact between the rolls. There will also be bending of the rolls, which adds to the spring. The load is then transferred *via* the roll-neck bearings to the chocks and mill housing proper, and after distortion of the roll bearings there will be compression of the screw, extension of the housing posts and bending of the top and bottom cross-pieces. All distortions in the housing are in accordance with Hooke's Law or from the bending of beams and the housing spring will be directly proportional to the rolling load. In the case of the roll flattening, however, the deflexion is not directly proportional to the load, but there is a slight curvature. The resultant calculated relationship between mill spring and load will then deviate slightly from the straight line, because of the flattening of the rolls and flattening at the roll-neck bearing. In practice, there will also be a substantial spring when the load is first applied, due to bedding down of various components and surfaces in contact and it is virtually impossible to estimate the extent of this effect giving a " toe " to the curve.

If a mill is fitted with some means of measuring the rolling load, it is a simple matter to plot the mill spring/load curve by direct experiment.

As already mentioned, if the rolls are forced together, S is a negative and the mill spring is, therefore, the sum of the final gauge and the amount by which the screws move after the rolls make contact. If the mill is run with the rolls in contact, but no material between the rolls, the outgoing gauge can be taken to be zero. Then $h = 0$ and mill spring $= S_1$ where S_1 is the distance the screws move after the rolls make contact.

In order to plot the load/spring curve, it is then only necessary to run the mill under different degrees of pre-load and measure the rolling load for each screw position. This can be plotted directly as the load/spring curve for that particular mill.

Although this is a very simple test to carry out, the curve which is obtained will not be truly representative of the mill spring when material

* Formerly Assistant Manager, Cold Rolling, The Steel Company of Wales Ltd., Abbey Works.

is being rolled. When a bar or sheet is being rolled, it is usually substantially less in width than the roll barrel length and the rolling load is, therefore, concentrated over part of the rolls, causing roll bending and flattening, which will be greater than that obtained when the rolling load is spread over the whole width of the roll barrel, as when there is no material in the rolls.

Although the load/spring curve is usually assumed to be a unique, reversible and reproducible curve for a given mill, this is not true quite as the curve will vary slightly with every different width of material rolled, because of the above-mentioned variation in load distribution on the rolls. Provided the mill is fitted with loadmeters, it is not difficult to plot a series of mill-spring curves for different widths of material being rolled. One method is to set the rolls at a known gap, which is carefully measured by slip gauges and enter bars of various thickness, each being of sufficient length to enable rolling conditions to stabilize. The outgoing thickness of each bar corresponding to the steady load condition is then measured and the difference between the measured thickness and the roll setting will be the mill spring for that particular load. This method is quite satisfactory and gives the load/spring curve for a given bar width, but the range of load which can be obtained from a given roll setting is limited by the range of thickness of the bar which will enter.

An alternative method which is a little more tedious, but can be used to give the complete range of the curve from minimum to maximum load of the mill, is to use a fixed thickness of bar entering the mill and change the roll setting for each bar.

As before, the roll setting must be measured carefully and the final rolled gauge measured, the difference giving the mill spring for that particular load. In practice, it is sufficient to obtain the roll setting at each point in the test directly from the screw position. This will give the correct form of the mill-spring curve and if the roll gap is measured accurately at one point and related to the screw position at that point, the position of the curve in relation to the zero of the graph can be established.

Mill Modulus

For all practical purposes it can be said that the load/spring relationship for a given mill is a fixed straight line, if the toe of the curve is ignored. This can be seen from Fig. 1, which shows a typical load/spring curve for a 4-high cold mill. If then the load/spring curve is taken to be a straight line, the slope of the line being constant for any given mill, this slope is defined as the *Mill Modulus* for that particular mill. This Modulus is in tons per inch units and will actually be the load which would be required to cause a mill spring of 1 in., assuming that this was possible with the mill still behaving elastically. The Modulus for any given mill can, therefore, be obtained by plotting the load/spring relationship and drawing the mean straight line over the normal working range, the slope being measured directly.

If there was no " toe " to the curve and this mean straight line passed through the zero point, the complete relationship between the load and the spring would be known from the mill modulus. In actual fact, however, the straight line will

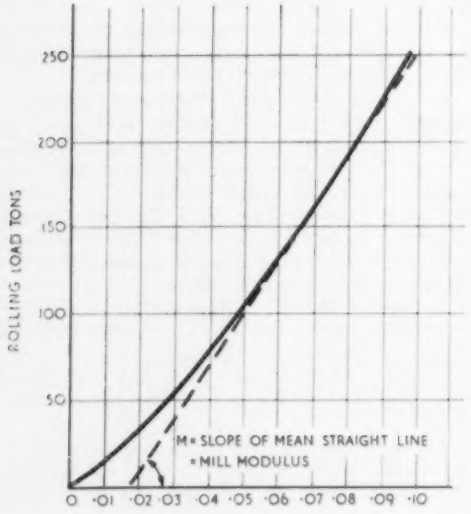
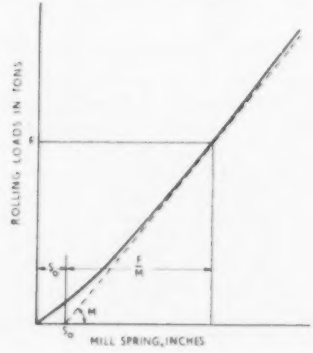


Fig. 1. (left)—A typical load/spring curve for a small 4-high mill

Fig. 2 (below).—Curve showing how mill spring is obtained from the mill modulus. Mill spring at load $F = S_o + \frac{F}{M}$



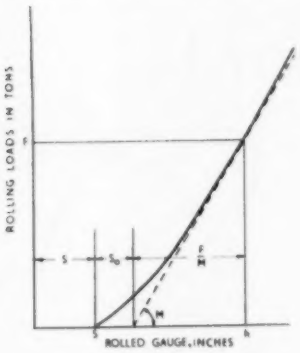
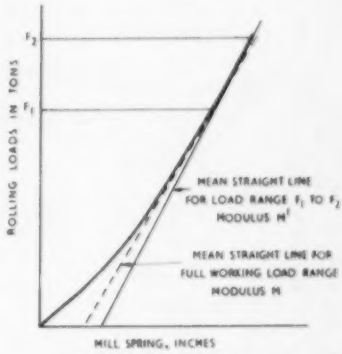


Fig. 3 (left).—Curve showing calculation of rolled gauge from the mill modulus. Rolled gauge h at rolling load F and roll setting S is given by

$$h = S + S_o + \frac{F}{M}$$

Fig. 4 (right).—Curve showing variation in mill modulus over different load ranges


ROLLING LOADS IN TONS
F_2
F_1
MEAN STRAIGHT LINE FOR LOAD RANGE F_1 TO F_2 MODULUS M^1
MEAN STRAIGHT LINE FOR FULL WORKING LOAD RANGE MODULUS M
MILL SPRING, INCHES

cut the x axis at some point, say S_o and the mill spring will then be S_o plus the spring obtained from the Modulus. That is,

$$\text{Spring} = S_o + \frac{F}{M}$$

as seen from Fig. 2.

Taking this further, much more information can be obtained if the initial roll setting is introduced into the modulus curve. If there is an initial roll gap of S, the modulus curve will start at S instead of zero, as shown in Fig. 3. A family of such curves can then be obtained for any given mill for various roll settings, and the finished gauge for any roll setting and rolling load can be obtained directly from this family of curves. In practice, it is more convenient to be able to calculate gauge directly without drawing the family of curves and for this it is necessary to know the values of S_o and M for that particular mill.

If mill spring is $S_o + \frac{F}{M}$ and the roll gap setting is S, then the finished gauge $h = S + S_o + \frac{F}{M}$ ..(1)

where F is the rolling load.

Use of equation (1) to obtain the finished gauge will give reasonably accurate results, but in practice there are several factors which influence its accuracy.

(1) It has already been shown that the equation is based on a linear relationship between load and spring, whereas in practice it is known that there is a slight curvature. Normally a mill works over a restricted load range and the error due to curvature of the graph will be small, provided that the value of M for this small range is used. It may be different from the mean value of M for the whole range, as seen from Fig. 4.

(2) It will be affected by the temperature of the rolls and the mill. When a mill starts up from cold, the rolls heat up quickly and the housings heat up more slowly until they reach normal running temperature. It has been shown that after several hours the temperature of the mill becomes fairly constant, but the roll temperature fluctuates considerably with the rolling schedule, and rolling speed. It will be obvious that when a roll heats up, its diameter increases and for a fixed screw setting this reduces the roll gap S. If this roll gap was measured directly this would not be important, but in practice it is usual to measure the gap from the screw position and a change in diameter of the roll will, therefore, affect the roll gap. Similarly, when the housing is warming up it will expand slightly allowing the roll gap to increase for a given screw setting.

(3) A further source of error is eccentricity between the back-up roll neck and barrel and any ovality of the rolls. If the rolls are oval, it is obvious that there will be a cyclical variation in the roll gap, the frequency of the cycle and the amplitude depending on the relative position of the oval rolls to each other. The eccentricity of the back-up roll barrel referred to the roll neck which is running in the bearing, will have exactly the same effect. Any eccentricity between the barrel and the neck of the work rolls in a 4-high mill, however, should not have this effect, as it will be taken up by the vertical movement of the chock carrying the work-roll-neck bearing in its slides.

Modulus of Rolls and Housing

It has been shown that the spring of the mill is the sum of the spring of the rolls and the spring of the housing. If, however, the load/spring curve is drawn for the housing and rolls separately and the Modulus obtained for each, the Mill Modulus will not be a direct addition of the Modulus of the rolls and the Modulus of the housing. A rolling mill will behave in an identical fashion to two coil springs in series, subject to external forces. Then if M_h is the modulus of the housing and M_R is the modulus of the rolls,

$$\frac{1}{M} = \frac{1}{M_h} + \frac{1}{M_R}$$

In practice, as already explained, it is relatively

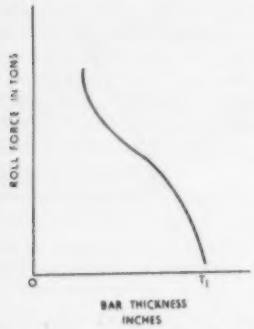


Fig. 5.—The general form of the plastic curve for a material being rolled

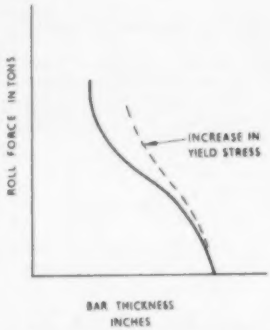


Fig. 6.—Showing the effect of a change in yield stress on the plastic curve

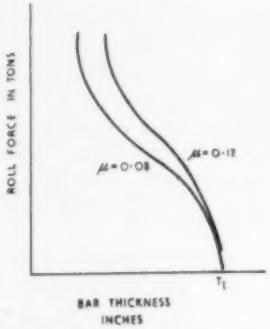


Fig. 7.—Showing the effect of a change in friction on the plastic curve

simple to obtain the value of M by direct measurements and it is this value which is normally used. In rolling-mill design calculations, however, it may be useful to know the relationship between the modulus of the rolls, the housing and the mill.

The Plastic Curve

Some of the factors which influence rolling load have already been mentioned. Many equations have been proposed linking all these variables, but it is obvious that they will be extremely complex and the accuracy cannot be expected to be of a very high order. It is, however, possible to obtain a curve of rolling load against reduction, which will represent the equation connecting rolling load and all the factors which influence it. The general shape of a plastic curve is shown in Fig. 5 and represents the equations connecting the rolling load and the variables which effect it. The qualitative effect of various factors on this curve can be seen from Figs. 6, 7, 8 and 9. Figs. 6 and 7 show that an increase in yield stress has a similar effect as an increase in friction; both require a greater roll force for a given reduction. Fig. 8 shows the effect of starting with different thicknesses of bar. When the limit is reached on very thin strip, the curve becomes a vertical line and however great the applied force, it is impossible to obtain any further reduction in thickness. Fig. 9 shows that as applied tension is increased, the roll force required is reduced.

Specific Roll Pressure

The plastic curve has been shown plotted against Roll Force, but in many rolling calculations and graphs it is more convenient to plot *Mean Specific Roll Pressure* rather than roll force, as this makes some allowance for roll diameter and draft.

The mean specific roll pressure is defined as the rolling load divided by the contact area.

It is sufficiently accurate to take the contact area equal to the width of the material being rolled, multiplied by the horizontal projection of the arc of contact.

Then $x = R(T_1 - T_2) - (T_1 - T_2)^2$

where x is the horizontal projection of the arc of contact and

Fig. 8.—Showing the effect of different ingoing bar thickness on the plastic curve

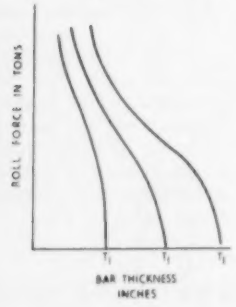


Fig. 9.—Showing the effect of tension on the plastic curve

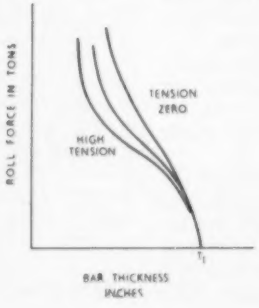
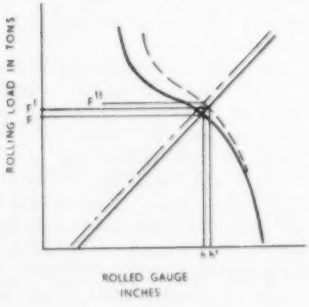


Fig. 10.—Elastic/plastic curves showing the effect of a change in friction on gauge



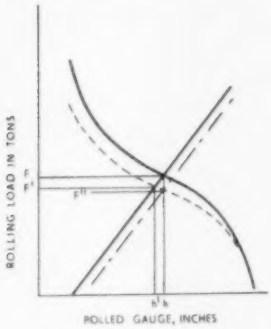
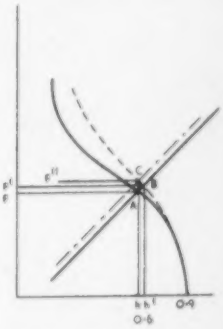


Fig. 11 (left).—Elastic/plastic curves showing the effect of increased tension on gauge

Fig. 12 (right).—Elastic/plastic curves showing the effect of an increase in yield stress on gauge



T_1, T_2 are the bar thicknesses before and after rolling. This can be simplified to

$x = R(T_1 - T_2)$ within the limits of accuracy required.

Then

$$p_s = \frac{P}{W_1 R(T_1 - T_2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where P = roll force

p_s = mean specific roll pressure.

The plastic curves for the material being rolled can now be plotted on the same graph as the elastic curves of the mill and from the various families of curves, a great deal of information can be obtained. A number of examples will show some of the uses of these curves.

Fig. 10 shows the elastic and plastic curves for a given mill rolling a certain strip. If for some reason, such as a breakdown in lubrication, the coefficient of friction is increased, this will be shown by the dotted line in Fig. 10.

From the original curves, at roll force F the final strip thickness was h, but for the same roll setting it will be seen that the new point of equilibrium gives a greater roll force F′ with a greater final thickness h'. The effect of an increase in friction, therefore, is to increase the roll force for a given roll setting and also to reduce the reduction obtained in the pass. If the rollerman wished to maintain his outgoing gauge constant, he would change his roll setting by screwing down more and the new elastic curve shown by the chain dotted line will intersect the plastic curve at a new force F″ at the required outgoing thickness h. The information which can be obtained from Fig. 10 is then summarized as follows :—

If the coefficient of friction increases, for a given roll setting the roll force will increase and the reduction in the pass will be reduced. If a constant outgoing thickness is required, the roll-gap setting will have to be reduced by screwing down and the roll force will be increased.

Fig. 11 shows the elastic and plastic curves for a mill cold rolling strip under tension. The equilibrium condition between the elastic and plastic curves for a certain front tension is shown by the full lines, with a roll force F and a rolled gauge h. If the tension increases at a fixed roll-gap setting, the plastic curve will move, as shown by the dotted line. The new position of equilibrium then gives a roll force F′ and a finished thickness h'. The effect of an increase in tension for any roll setting is, therefore, to reduce the roll force and to increase the reduction in the pass. If a constant outgoing gauge is required, the screws will have to be raised slightly, giving a new elastic curve, as shown by the chain dotted line. The roll force F″ will then give the required thickness h.

Fig. 12 shows the elastic and plastic curves for a hot mill rolling sheet which has a certain yield stress. If this sheet were suddenly to become harder, perhaps due to cooler zones, the new plastic curve will be as shown dotted. This will have the effect of increasing the roll force F to F′ and increasing the final gauge from h to h' at a constant roll setting. If a constant outgoing gauge is required, the screws will have to be brought down to give the new elastic curve shown by the chain dotted line and the new roll force required will be F″.

The effect of any factor on the elastic or plastic curves can be shown qualitatively very easily by freehand sketches of the above graphs, but it is also possible to obtain the quantitative analysis provided that the curves are drawn to scale.

The question of setting up the individual mills of a continuous strip mill is complex, but it is of interest here to show how the qualitative settings of the screw can be obtained from the elastic/plastic curves. Consider the case of a continuous strip mill, where the slab on the delay table is 0.9 in. thick and it is reduced to 0.6 in. in the first mill of the finishing-mill train. This can be represented by the elastic/plastic curves, as shown in Fig. 12. The position of equilibrium A, shows a thickness of 0.6 in. under a rolling load F. The next bar on the delay table may vary in several ways, the

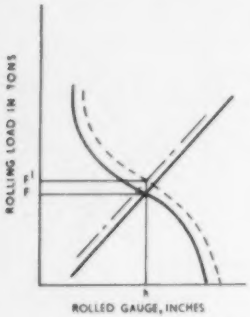
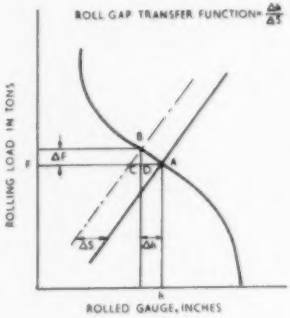


Fig. 13 (left).—Elastic/plastic curves showing the effect of an increase in ingoing gauge on the rolled gauge

Fig. 14 (right).—Elastic/plastic curves showing the roll-gap transfer function



most usual variations being in width, thickness, temperature and steel grade. If, for example, the second bar is identical to the first, but cooler, the plastic curve will move, as shown by the dotted line in Fig. 12 and the new position of equilibrium B will be F′ with a new thickness h', which is greater than 0.6 in. In order to obtain the correct gauge from this mill, the screws must be brought down, as shown by the chain dotted line in Fig. 12, with a new equilibrium position at point C.

If the second bar is wider than the preceding one, again the movement of the plastic curve will be in the same direction as for the cold bar and similar corrective movements of the screws will have to be made. Similarly, if the second bar is of a different analysis, giving a higher yield stress, there will be a similar movement of the plastic curve and again a similar correction by the screws.

If the second bar is thicker than the preceding one, the plastic curve will move bodily, as shown by the dotted line in Fig. 13, and it will remain substantially parallel to the original plastic curve. Again a correction will have to be made by screwing down, as shown by the chain dotted line in Fig. 13.

The direction of movement of the screws for any variation in the ingoing bar can be worked out along these lines, but the actual distance the screws must be moved can only be obtained by an accurate plot of these graphs and in practice this would involve a considerable amount of experimental work to plot a large number of plastic curves. In order to obtain full automatic control of a mill, this will eventually have to be done and the value of the roll-gap transfer function obtained under any rolling condition.

Roll-gap Transfer Function

Every rollerman knows in practice that if he wishes to change the gauge of a sheet by say 0.002 in., he will have to screw down a greater distance than this, the actual amount varying from a little more than 0.002 in. on thick hot sheet to a very high figure when the sheet is thin and hard. This is a mill spring effect and is given the technical term the *Roll Gap Transfer Function*.

The magnitude of the roll-gap transfer function and its variation under different conditions can be examined by means of the elastic/plastic curves. Fig. 14 shows the elastic/plastic curve for a hypothetical case, where the finished gauge is h at a rolling load F. A is the equilibrium point. If the screws are brought down a distance $\triangle$S, the elastic line will be moved to a new position shown dotted in Fig. 14 and it now intersects the plastic curve at point B. The change in roll force from A to B will be $\triangle$F. If a straight line is drawn from A to B, in practice this distance is small and the straight line will correspond very closely to the plastic curve

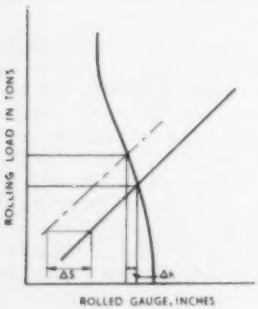
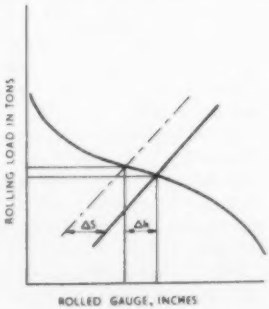


Fig. 15 (left).—Elastic/plastic curves showing the roll-gap transfer function for a thin hard material

Fig. 16 (right).—Elastic/plastic curves showing the roll-gap transfer function for a soft material



between A and B. If Q is the slope of this line, then

$$\frac{\triangle F}{\triangle h} = Q$$

From the geometry of Fig. 14 it will be seen that $\triangle S = CD + DA$ and as M is the slope of the line CB,

$$\triangle S = \frac{\triangle F}{M} + \triangle h$$

Eliminating $\triangle F$ from the above two equations gives

$$\triangle S = \frac{Q \triangle h}{M} + \triangle h$$

$$\text{or } \frac{\triangle S}{\triangle h} = \frac{Q}{M} + 1$$

The roll-gap transfer function can be defined as the screw movement required to give a certain change in roll thickness.

Then,

$$\text{Roll-gap Transfer Function} = \frac{\text{Change in thickness}}{\text{Movement inscrew}} = \frac{\triangle h}{\triangle S}$$

Then from the above equation the roll gap transfer function $= \frac{\triangle h}{\triangle S} = \frac{M}{M + Q}$

Taking a numerical example, if the roll-gap transfer function is $\frac{1}{5}$ it means that,

$$\frac{\triangle h}{\triangle S} = \frac{1}{5}$$

$$\text{or } \triangle S = 5 \triangle h$$

i.e., the screw movement required is five times the change in thickness required.

As every rollerman knows, on a thick soft material the screws are only required to move a relatively small distance to make a correction in gauge, or in other words the roll-gap transfer function approaches $\frac{1.}{1}$ On the other hand, when the limiting thickness condition is approaching, the screws must be moved a considerable distance to make any correction and the roll-gap transfer function begins to fall at an ever-increasing rate until the limiting thickness is reached, and however far the screws are moved, there is no change in gauge. The roll-gap transfer function then becomes zero.

This effect can be seen from the elastic/plastic curve. Fig. 15 shows the plastic curve for a very thin hard material and it is immediately obvious from this diagram that $\triangle h$ is small compared with $\triangle S$. Similarly, for a thick soft material the plastic curve will be shown in Fig. 16 and it will be seen from this that $\triangle h$ approaches more nearly to the value of $\triangle S$. Referring now to the equation for the roll-gap transfer function, it will be seen that for a thin hard material giving a curve as in Fig. 15, Q will be large and if the line became vertical, would be infinity. In the case of the soft material, shown in Fig. 16, the value of Q is small and if it was zero, the plastic curve would be horizontal at that point. In practice, it is possible for Q to be infinity under limiting thickness conditions, but it is never possible to reach the case when Q is zero.

The Effect of Mill Stiffness on Gauge

If an infinitely stiff mill was possible in practice there would be no spring whatever and the rolled gauge would be exactly the same as the initial roll-gap setting. The nearest practical approach to this is a stiff design, such as the pre-stressed SKF mill in which the housing spring can be made very small. Experiments have been carried out with tungsten-carbide rolls which have a very high modulus of elasticity and, therefore, a greater resistance to flattening under load. By using these rolls in conjunction with heavy backing rolls and a pre-stressed housing, the nett result is a very stiff mill in which the rolled gauge is only slightly greater than the roll-gap setting. In a stiff mill a great deal of energy is stored in the mill and variations in ingoing gauge are "ironed out" to a great extent. This can be seen by consideration of the mill modulus. A sudden increase in ingoing thickness tends to force the rolls further apart, but if the mill modulus is high, as in a stiff mill, a much greater force is required to move the rolls a given distance apart than in a soft mill and the variation in the ingoing gauge is reduced considerably as the material passes through the rolls. In a stiff mill the screw movement required for a given correction will be relatively small, but will require a great deal of torque on the screw.

In the case of a soft mill, the rolled gauge is considerably greater than the initial roll-gap setting. This in itself is not a serious disadvantage in a mill, provided that the rollerman knows the amount of spring he will have for different rolling schedules and sets the mill accordingly. There is, however, the disadvantage that in a soft mill any variations in ingoing gauge will persist through the mill and will not be ironed out as in a stiff mill. Again, this will be seen by consideration of the mill modulus which will be small and a relatively small change in ingoing thickness will be sufficient to force the rolls apart and give an error in the finished gauge. In a soft mill the screw movement required for a given correction will be relatively large, but the torque required will be small. The overall power required at the screw will be almost identical whether the mill is stiff or soft.

The elastic/plastic curves can be used to illustrate the effect of mill stiffness.

Fig. 17 shows the hypothetical case of a stiff mill with an equilibrium position at rolling load F

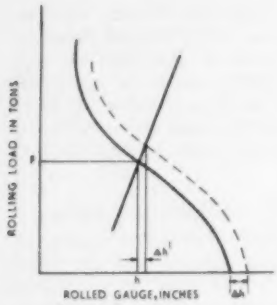
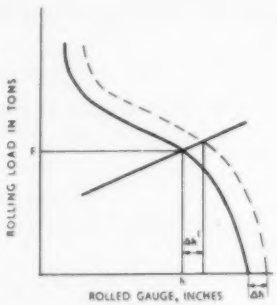


Fig. 17 (left).—Elastic/plastic curves showing the effect of a change in ingoing gauge in a stiff mill

Fig. 18 (right).—Elastic/plastic curves showing the effect of a change in ingoing gauge in a soft mill



and rolled gauge h. The modulus is high, giving a steep slope to the elastic line. If now there is a change in ingoing thickness, the plastic curve will move parallel to itself a distance $\triangle h$ equal to the change in ingoing thickness, as shown dotted in Fig. 17. Assuming no change in screw setting, the change in rolled gauge will then be $\triangle h'$, as shown in the diagram and it will be seen that $\triangle h'$ will be less than $\triangle h$. The stiffer the mill the more nearly does this elastic line approach the vertical and, of course, if it was possible to have an infinitely stiff mill giving a vertical line, $\triangle h'$ would be zero for any value of $\triangle h$ and any ingoing variation would be ironed out completely. In the case of a soft mill the elastic line has a much smaller slope and it will be seen from Fig. 18 that a change of $\triangle h$ in ingoing thickness gives a change of $\triangle h'$ in rolled thickness, where $\triangle h'$ may approach, or in extreme conditions very rarely found in practice, may be greater than $\triangle h$.

The Effect of Mill Stiffness on the Automatic Control of Gauge

The fact that a mill springs has been used ingeniously by the British Iron and Steel Research Association in a high-speed form of automatic control of gauge. It has been shown that the gauge coming out of a mill at any instant is the sum of the roll gap setting and the mill spring at that instant. When investigating the possibility of automatic gauge control, the British Iron and Steel Research Association scientists evolved this equation and decided to try and measure the roll setting and the mill spring electrically, so that they could be added together electronically at high speed to give a measurement of gauge.

The measurement of the roll setting at any instant is relatively simple in a normal screw-type mill, as the roll-adjusting screws themselves can be used as micrometers. Provided the measurement is made at a point where there is no backlash, the screws give a high degree of accuracy and in several mills which have been checked by accurate instruments the positional errors are only fractions of a thousandth of an inch. In order to avoid backlash in the initial experiments, an electrical resistance wire was mounted on a drum which was bolted directly to the top of each screw. A pick-up touched this resistance wire and shorted out a portion of it, depending on the screw position; an accurate measurement of the resistance of the remaining portion of the wire gave an electric signal directly proportional to the screw position. This method can give a high degree of accuracy, but is not robust enough for a production mill and it is now usual to use a Selsyn on the end of the screw, which measures the number of degrees the screw moves from a zero position.

It is a difficult matter to measure mill spring directly and transform it to an electric signal, but it is relatively easy to measure the rolling load and obtain an electric signal proportional to this load. If the mill modulus curve is a unique reversible and repeatable straightline for any given mill and the slope of this line is M, the mill spring at any instant will be $\frac{F}{M}$ where F is the roll force at that instant. As M is a constant for a given mill, it is obvious that the mill spring is directly proportional to the rolling load and if an electrical signal is obtained which is proportional to the rolling load, this can be converted directly to mill spring.

Many methods of measuring roll load have been developed, but by using electrical-resistance strain gauge load meters a high accuracy can be obtained with a fast response.

The British Iron and Steel Research Association automatic-gauge-control system, therefore, consists of some means of measuring rolling load electronically, together with some means of measuring the screw position electrically and adding these together to give the final rolled gauge.

Having obtained a rapid and accurate measurement of gauge at any instant, there are several ways in which this can be used to control the gauge to a pre-determined figure. In a normal screw-operated mill it is possible to have a Ward-Leonard drive to the screws with a signal feeding back

constantly from the gauge measuring system. In this case the gauge required is set on a dial, giving an electrical signal proportional to this gauge and this is compared with the gauge measurement, any difference between the two being corrected by feeding the error in to the Ward-Leonard system of the screwdown. The disadvantage of this is that the screws are moving continually and screw thread wear becomes a problem. As there is always a rolling tolerance on gauge, it is more usual to have a gate set to a predetermined tolerance on each side of the nominal gauge and the screw motors are only energized when the measured gauge falls outside this tolerance.

In theory, this automatic-gauge-control system will work equally well whether the mill is soft or hard. The electronic system is fast enough to measure the gauge and initiate a rapid correction. but in a normal screw-type mill, there is a considerable lag in transferring the correction signal through the contactor gear to powerful screwdown motors. If, therefore, the mill is very soft, with little inherent " ironing out " of gauge, the automatic gauge control will be lagging behind the gauge changes. If, however, the mill is very stiff there will be a considerable " ironing out " of gauge errors and the gauge control correction will be required less often. A stiff mill is, therefore, preferable to ease the work done by the gauge control.

In order to make use of the speed of response of the BISRA system of automatic control, it would be preferable to use a hydraulic method of loading the rolls. There are many mills operating with simple hydraulic jacks, but so far the development of a hydraulic system of gauge control has not reached a production basis. Initial tests, however, have shown that it is preferable to keep the mill as stiff as possible and the aim has been to keep the volume of fluid in the system as small as possible and to lock the system completely when rolling under constant load. In theory it is possible to make a hydraulic loading system so rapid that a soft mill can be used, but again this throws extra work on the control system.

Mill Spring and Taper Rolling

In all normal work, the rollerman's aim is to maintain a constant gauge, both across the width and along the length of a bar or sheet. There are, however, occasions when a taper may be required, particularly in the aircraft industry. The present trend is to design wings with light-alloy sheet covering, which tapers in thickness from the root of the wing to the tip. Similarly, light-alloy main wing spars are required, which taper from the root to the tip. It is common practice when making a wing spar to take a rolled section and mill it to obtain the taper along the length. This takes a great deal of time and the wastage is high, as something in the order of half the total weight is removed in the milling process. Similarly, thin light-alloy sheets have been milled to a taper gauge, but this is even more costly than machining a spar. Various experiments have been carried out with the object of rolling the sheet or spar to the correct taper, but so far little progress has been made on a production basis. When rolling a taper it is not a simple matter of screwing down as the material passes through the rolls to give the variation required from end to end, as this involves extremely high rolling loads at the thin end of the wedge and there is difficulty in obtaining an accurate taper. In addition to this, the mechanical properties of the material would vary considerably along the length from relatively soft at the thick end to very hard at the thin end. The various methods of rolling a taper will now be discussed with particular reference to the mill spring.

There are several possible methods of obtaining an accurate taper in several passes and most of these would apply to hot rolling of taper billets from parallel stock, or cold rolling of strip from constant gauge material. These methods can be broken down into two major divisions.

(1) The material can be rolled down normally to give parallel stock of the correct thickness for the thick end of the wedge, all tapering being carried out in the final passes.

(2) The taper can be formed roughly early in the breaking down process, all subsequent reduction being carried out on the tapered material.

Method 1 appears on the face of it to be the most attractive commercially, as the major part of the reduction is on a normal mill at high speed. By this method, however, there will be a substantial variation in the mechanical properties along the length of the finished bar or sheet and it will be necessary to anneal and taper skin pass to obtain a reasonably uniform product.

Method 2 seems to be rather more complicated, but in this case the major part of the reduction is on stock of approximately the correct taper and the draft throughout each pass is more or less constant after the taper has been formed roughly in the early stages of breaking down.

The choice between the two possible methods will depend on the mechanical properties required and the type of mill and control used.

Whichever of the above methods is used to give the final taper, at some stage in the rolling it will be necessary to change from parallel stock to stock with the finished taper and the actual forming of the taper can be carried out in one of three ways.

(1) Fig. 19 (*a*) shows a finished wedge-shaped bar, the taper of which has obviously been greatly exaggerated for clarity. Starting with parallel stock a little above the finished wedge thickness, the screws are operated on pass 1 at a point which

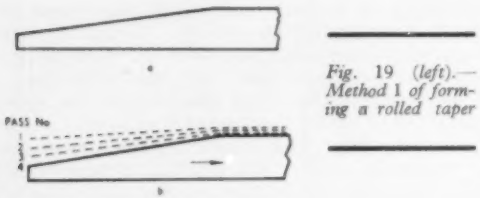


Fig. 19 (left).—Method 1 of forming a rolled taper

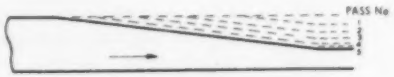


Fig. 20 (above).—Method 2 of producing a rolled taper

Fig. 21 (below).—Method 3 of forming a rolled taper

will produce a shallow taper and on each succeeding pass the screws are operated at the same point, giving an increased taper on each pass until the final form is reached, as shown in Fig. 19 (*b*). By this method, as the heaviest rolling loads are at the thin edge of the wedge, the point at which the screwdown starts for each pass is not critical, provided that the point for the final pass is forward of all the others. This method is not very attractive on a production basis, as the rate of screwdown must be varied for each pass.

An alternative is to roll in the other direction, following the same pass profile, with the screws lifting instead of lowering during each pass. The only difference here is that the parallel stock would equal the thickness of the finished wedge and the bar would run right through the rolls on each pass.

(2) In this case, the stock is rolled parallel to the thickness of the thick end of the taper. On pass 1 a normal reduction is taken and at point 1 in Fig. 20 the screws begin to lift at the rate required to give the correct taper. This is repeated on each pass, as shown in the diagram, until the required cross-section is obtained. Again, this is not very attractive on a production basis, as the point at which the screws begin to lift is rather critical, there being a strong possibility of breaking the rolls if the lift is delayed. In theory, however, an automatic switch for the screws could be used operating as soon as the rolling load begins to rise above a certain fixed value.

(3) In this case the parallel stock is rolled a little thicker than the finished wedge thickness. On pass 1, the screwdown starts at point 1 and the correct final taper is formed over a short distance. On the second pass the screwdown starts at point 2 and so on, as shown in Fig. 21.

Calculation of Screwdown Rate Required for a Given Taper

If rolling mills were infinitely stiff and the material left the mill at the roll circumferential speed, it would be a simple matter to calculate the speed ratio between the main mill-motor speed and the screws to give any required taper.

Let N r.p.m. = mill-motor speed.
n r.p.m. = screw speed.
p ft. = screw pitch.
D ft. = roll diameter.
t min. = time of rolling.
Required taper 1 ft. in L ft.

The length rolled in time $t = \pi DNt$ ft.
Distance moved by screw in time $t = npt$ ft.
For a taper of 1 ft. in L ft. the screw movement required in time $t = \dfrac{\pi DNt}{L}$

then $\dfrac{\pi DNt}{L} = npt$

from which $\dfrac{N}{n} = \dfrac{Lp}{\pi D}$ .....(3)

In practice this will not give the correct taper because of several variables, the major ones being :—

1. Forward slip.
2. Mill spring.
3. Roll temperature variation.

1. Forward slip will only be mentioned briefly here, as it is not a mill-spring effect. If the screwdown speed is calculated without any allowance for forward slip and the taper required is as shown in Fig. 22, the taper actually rolled would be as shown dotted in this figure. This error due to forward slip can easily be calculated.

If H = intitial thickness, after rolling for time t, $h_2 = H - \dfrac{x}{L}$ to give a taper of 1 ft. in L ft.

where x and x_1 is shown in Fig. 22.

If S is the forward slip.

$V = v(1 + S)$,

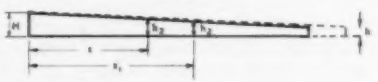
and as distances will be proportional to velocities,

$x_1 = x(1 + S)$.

Time t is unchanged, therefore, the thickness at x_1 is still h_2, but for the correct taper it should be $H - \dfrac{x_1}{L}$

therefore, the error $h = h_2 - \left(H - \dfrac{x_1}{L}\right)$

Fig. 22.—Effect of forward slip on the accuracy of a rolled taper



Substituting for x_1 and h_2.

$$h = \frac{Sx}{L}$$

This formula gives the maximum error at any point in a sheet, which would be obtained if the screwdown rates were calculated with no allowance for slip.

In practice S will not be constant throughout a pass when taper rolling, as it varies with draft and the variation will depend on the method used to produce the taper.

If either of methods 2 or 3 are used, the draft will be constant over part of the length of each pass and will fall gradually to zero at the beginning or end of the pass respectively. As forward slip will decrease with decreasing draft in the range in question, use of the above formula when rolling by either of these methods will over-estimate the error. If method 1 is used, the draft varies from zero to maximum during each pass and in this case a reasonable approximation will be to use a forward slip equivalent to a reduction at the mid-point of each pass.

2. Although the effect of forward slip on the accuracy of a rolled taper is relatively small, it is imperative that the effect of mill spring should be included in calculating the correct screw speed. Consider first the quantitative effect of mill spring, when the screw movement has been calculated assuming an infinitely stiff mill. In Fig. 23 the screws are set to move a distance $\frac{x}{L}$ in a length x to give the required taper 1 ft. in L ft.

If f is the roll-gap transfer function, then the actual change in gauge for a screw movement of $\frac{x}{L}$ will be $\frac{xf}{L}$.

The error in gauge at this particular point will then be $\frac{x}{L} - \frac{xf}{L} = \frac{x}{L}(1-f)$.

When the material being rolled is thin and hard, as it would be at the thin end of the sheet, f may fall to $\frac{1}{10}$ or less and this would be sufficient to give a completely incorrect taper.

Example

If a 10-ft. long sheet is being rolled with a taper in gauge from 0.060 to 0.030 in., what will be the maximum gauge error if the mean value of the roll-gap transfer function is $\frac{1}{4}$?

The taper is 0.030 in. in 10 ft., therefore, L = 4,000. $x = 120$ in.

then maximum error $= \frac{120}{4{,}000} \times \frac{3}{4} = 0.022$ in.

One method of obtaining the correct taper and compensating for mill spring is by setting the screw speeds by trial-and-error methods to give the correct thickness at the beginning and at the end of the taper. The screw movement required to give the correct gauge at the thin end of the taper can then be noted and from this the roll-gap transfer function at this point can be calculated. If this is f, the screw movement required will be $\frac{x}{L} \times \frac{1}{f}$. The mill can then be set up to give a constant rate of screwdown with a maximum movement of $\frac{X}{L} \cdot \frac{1}{f}$ at the end of the pass. On the face of it this would appear to give the correct taper, but in actual fact errors at various points along the sheet can be quite considerable.

Referring to Fig. 24, f_x is the roll-gap transfer function at a given point distance x along the sheet. At this point the screws will have moved a distance $\frac{x}{X} \cdot \frac{X}{L} \cdot \frac{1}{f}$ which equals $\frac{x}{L} \cdot \frac{1}{f}$.

However, in order to obtain the correct gauge at this point the screw movement required is $\frac{x}{L} \cdot \frac{1}{f_x}$

The gauge error at this point will then be

$$\frac{x}{L} \cdot \frac{1}{f} - \frac{x}{L} \cdot \frac{1}{f_x} = \left(\frac{1}{f} - \frac{1}{f_x}\right)\frac{x}{L}$$

A numerical example will show the magnitude of the errors which might be expected.

Example

If a 10-ft. long sheet is being rolled with a taper from 0.060 to 0.030 in. and the screws are set to give a constant rate of screwdown with the correct final gauge of 0.030 in., find the gauge error at the mid-point of the sheet.

$x = 60$ in. L = 0.030 in 120 = 1 in 4,000

assume $f = \frac{1}{6}$ and $f_x = \frac{1}{5}$

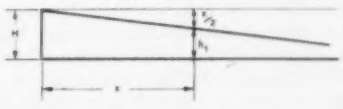


Fig. 23 (above).—Screw movement required—assuming an infinitely stiff mill

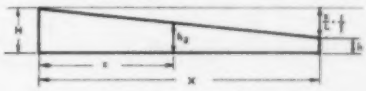


Fig. 24 (below).—Gauge error in a rolled taper due to variation in the roll-gap transfer function

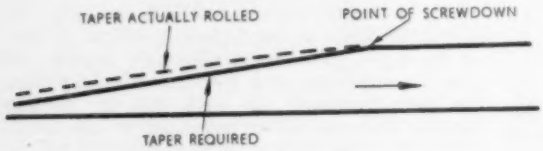


Fig. 25.—Error in a rolled taper due to mill spring at small reductions

then the error $= \frac{6}{400}\left(\frac{1}{6} - \frac{1}{5}\right) = -0.005$ in.

and as this is negative, it indicates that the taper will be slightly convex.

This is a considerable over-simplification of the problem, as in practice the roll-gap transfer function will vary continuously from end to end of the bar. A full mathematical analysis would require some knowledge of the calculus, but the simple calculation given is sufficient to show the type of problem which exists and it gives some indication of the magnitude of the error.

In discussing the formation of a taper and the effect of the roll-gap transfer function, it has been assumed that the mill spring is directly proportional to the load. The shape of the mill-spring load curve has already been discussed at some length and shown to have a considerable curvature at the toe. If the load is maintained at a sufficiently high level to avoid the toe of the curve, the assumption that mill spring is directly proportional to load will be correct and the above argument will hold. If, however, the load falls to a small value, the mill spring becomes progressively greater in relation to the load and the roll-gap transfer function falls at an increasing rate as the load approaches zero.

The effect of this rapid variation in the roll-gap transfer function will vary with the different methods of rolling the taper.

In Method 1, the initial load on the mill is just sufficient to pull the bar through the rolls until the point is reached when the screwdowns are operated to form a taper. The error in the taper formed in the first pass would then take the form of the dotted line in Fig. 25. This effect would be cumulative from pass to pass and would completely alter the shape of the final taper. If this method of forming a taper was used in practice, one solution would be to roll a long sheet or bar and crop the end to waste.

If the taper is formed by Method 2, there will be a similar effect. Fig. 26 shows the finished taper with the last pass shown dotted, and shaded. The rolling load will be almost constant for most of the pass until point A is reached, after which the load will fall gradually to zero. As the load falls, the mill spring increases and the final shape of the taper will be as shown dotted. In this case, however, the error is not cumulative, as the load begins to fall at a different point in each pass. The major error will be that due to the last pass and the errors due to intermediate passes will be considerably reduced in amplitude as they approach the thinner end of the wedge. In practice, the errors due to the intermediate passes will be small enough to be ignored and a reasonably accurate taper will be formed if the sheet is rolled too long and the end cropped to waste, as before.

If the third method of forming the taper is used, the error due to the increase in spring at the toe of the curve can be eliminated. To do this, the initial load will have to be just sufficient to obtain a point above the toe of the modulus curve. This means that the original parallel sheet or bar will have to be considerably thicker than the finished thickness of the tapered sheet or bar. The pass sequence to give the correct taper will then be shown in Fig. 27 and at all points the screwdown load will be directly proportional to the mill spring so that there will be no upward curve at the thick end of the taper.

In the above discussion the change in the roll-gap transfer function due to the curvature of the elastic line has been considered in relation to the accuracy of the final taper. In addition to this, however, the change in slope of the plastic line should be considered. Over the normal working range of a mill there is little change in the slope of the plastic line, but at light reductions the slope increases rapidly, giving a correspondingly rapid fall in the

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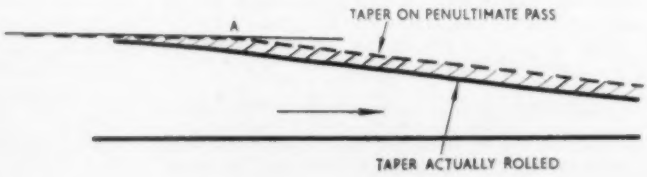
Fig. 26.—Error in a rolled taper due to mill spring



The Effect of Mill Spring on Gauge and the Rolling of Tapers

(*Continued from page* 290)

roll-gap transfer function assuming that the slope of the elastic line remains constant. In actual fact, however, the slope of the elastic line is falling at light reductions and the cumulative effect is to give a rapid reduction in the roll-gap transfer function as the rolling load approaches zero. The effect of the change in slope of the plastic line at small loads will, therefore, be to increase the rate of curvature of the errors shown in Figs. 25 and 26. This will be made clear by reference to the elastic/plastic diagrams already given.

This applies to the first pass when changing from a parallel bar to a taper. In the case of subsequent passes, when, in effect, the initial thickness is changing continually from one end of the bar to the other, there will not be a single plastic curve, but a constantly changing family of curves. If, for example, a bar is ½-in. thick at one end and ¼-in. thick at the other, the plastic curves corresponding to the ends of the bar may be shown in Fig. 27. The slope of each line at the appropriate rolling load must then be compared. In general, the slope will be increasing as the initial thickness falls, and the effect is to reduce the roll-gap transfer function as before.

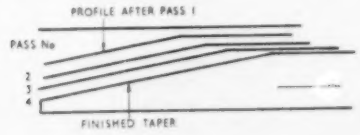
If the slope of the two curves at the appropriate rolling loads is different, but the change takes place at a constant rate throughout the pass, this will be allowed for in the "trial and error" method of setting up and the finished taper will be correct.

It follows from this discussion that if the screw-down/mill speed ratio is adjusted by trial and error to give the correct initial and final thickness and a pass sequence is used so that all reductions are within the range 15 to 35 per cent the error in the form of the taper due to mill spring will be small enough to be neglected.

3. Errors in the form of the taper due to roll temperature variation will be random ones and are unlikely to be of any consequence in one pass. As a mill warms up from cold, however, there may be substantial changes in roll temperature and, therefore, in roll diameter and this will complicate the setting up of the taper from pass to pass. Once the normal working temperature has been reached, any further temperature variations only affect the outer skin of the rolls and the change in diameter is small. For all practical purposes, the effect of roll temperature variation on the setting up of a taper can be ignored.

There are other factors such as motor droop which will affect the form of a rolled taper, but they are irrelevant to this discussion.

Fig. 27.—Suggested pass sequence to give an accurate rolled taper



Mr. C. W. STARLING

IT is with great regret that we have to announce the death, at the age of 34, of Mr. C. W. Starling, who was assistant manager, cold rolling, at the Abbey Works of the Steel Company of Wales Ltd., and the author of the above article.

Mr. Starling, a graduate in Engineering at Sheffield University, served an 18-month apprenticeship with B.S.A., on completion of which he joined Armstrong Siddeley and later Napier's Ltd., on research work.

He was then appointed to head a research team into rolling mills technique with B.I.S.R.A. at Sheffield, and some years later became research engineer with W. H. A. Robertson and Co. Ltd.

In 1956 he joined the Steel Company of Wales Ltd. as a technical assistant, rolling mills.

Mr. Starling wrote many technical articles on mill design and theory of rolling, several of which have been published in *Sheet Metal Industries*, and at the time of his death, had almost completed a book on these subjects.

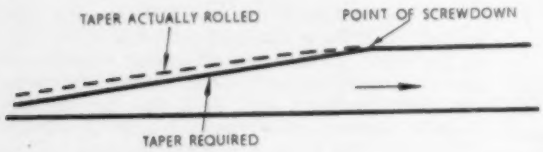
He leaves a widow and three children.

ISI TO VISIT ITALY

THIS year's Special Meeting of The Iron and Steel Institute, from May 29 to June 11, 1960, will be held in Italy. This is only the second time a meeting of the Institute has been held in Italy.

The meeting will open with a two-day joint meeting with the Associazione Italiana di Metallurgia, at which Mr. W. F. Cartwright, who takes office as president of the Institute at the Annual General Meeting on May 3, is to be awarded the Giolitti Medal of the AIM, one of the highest honours that body can award. There will also be joint technical meetings dealing with direct reduction, continuous casting, and vacuum casting.

Following the joint meeting, members of the Institute will visit many of the leading iron and steelmaking plants in Italy.



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In the above discussion the change in the roll-gap transfer function due to the curvature of the elastic line has been considered in relation to the accuracy of the final taper. In addition to this, however, the change in slope of the plastic line should be considered. Over the normal working range of a mill there is little change in the slope of the plastic line, but at light reductions the slope increases rapidly, giving a correspondingly rapid fall in the

(*Continued in page* 291)

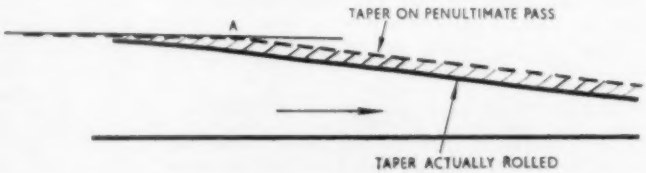


Fig. 26.—Error in a rolled taper due to mill spring

The Effect of Mill Spring on Gauge and the Rolling of Tapers

(*Continued from page* 290)

roll-gap transfer function assuming that the slope of the elastic line remains constant. In actual fact, however, the slope of the elastic line is falling at light reductions and the cumulative effect is to give a rapid reduction in the roll-gap transfer function as the rolling load approaches zero. The effect of the change in slope of the plastic line at small loads will, therefore, be to increase the rate of curvature of the errors shown in Figs. 25 and 26. This will be made clear by reference to the elastic/plastic diagrams already given.

This applies to the first pass when changing from a parallel bar to a taper. In the case of subsequent passes, when, in effect, the initial thickness is changing continually from one end of the bar to the other, there will not be a single plastic curve, but a constantly changing family of curves. If, for example, a bar is $\frac{1}{2}$-in. thick at one end and $\frac{1}{4}$-in. thick at the other, the plastic curves corresponding to the ends of the bar may be shown in Fig. 27. The slope of each line at the appropriate rolling load must then be compared. In general, the slope will be increasing as the initial thickness falls, and the effect is to reduce the roll-gap transfer function as before.

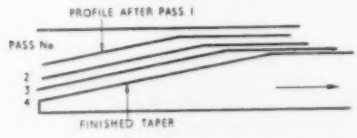
If the slope of the two curves at the appropriate rolling loads is different, but the change takes place at a constant rate throughout the pass, this will be allowed for in the "trial and error" method of setting up and the finished taper will be correct.

It follows from this discussion that if the screw-down/mill speed ratio is adjusted by trial and error to give the correct initial and final thickness and a pass sequence is used so that all reductions are within the range 15 to 35 per cent the error in the form of the taper due to mill spring will be small enough to be neglected.

3. Errors in the form of the taper due to roll temperature variation will be random ones and are unlikely to be of any consequence in one pass. As a mill warms up from cold, however, there may be substantial changes in roll temperature and, therefore, in roll diameter and this will complicate the setting up of the taper from pass to pass. Once the normal working temperature has been reached, any further temperature variations only affect the outer skin of the rolls and the change in diameter is small. For all practical purposes, the effect of roll temperature variation on the setting up of a taper can be ignored.

There are other factors such as motor droop which will affect the form of a rolled taper, but they are irrelevant to this discussion.

Fig. 27.—Suggested pass sequence to give an accurate rolled taper



Mr. C. W. STARLING

IT is with great regret that we have to announce the death, at the age of 34, of Mr. C. W. Starling, who was assistant manager, cold rolling, at the Abbey Works of the Steel Company of Wales Ltd., and the author of the above article.

Mr. Starling, a graduate in Engineering at Sheffield University, served an 18-month apprenticeship with B.S.A., on completion of which he joined Armstrong Siddeley and later Napier's Ltd., on research work.

He was then appointed to head a research team into rolling mills technique with B.I.S.R.A. at Sheffield, and some years later became research engineer with W. H. A. Robertson and Co. Ltd.

In 1956 he joined the Steel Company of Wales Ltd. as a technical assistant, rolling mills.

Mr. Starling wrote many technical articles on mill design and theory of rolling, several of which have been published in *Sheet Metal Industries*, and at the time of his death, had almost completed a book on these subjects.

He leaves a widow and three children.

ISI TO VISIT ITALY

THIS year's Special Meeting of The Iron and Steel Institute, from May 29 to June 11, 1960, will be held in Italy. This is only the second time a meeting of the Institute has been held in Italy.

The meeting will open with a two-day joint meeting with the Associazione Italiana di Metallurgia, at which Mr. W. F. Cartwright, who takes office as president of the Institute at the Annual General Meeting on May 3, is to be awarded the Giolitti Medal of the AIM, one of the highest honours that body can award. There will also be joint technical meetings dealing with direct reduction, continuous casting, and vacuum casting.

Following the joint meeting, members of the Institute will visit many of the leading iron and steelmaking plants in Italy.

PRODUCING SEGMENT BENDS

New Chart Presents Over 150,000 Different Bend Templates*

By P. G. WILSON

DESPITE the rapid advances made in the fabrication techniques of sheet and plate metal, the segment bend still fulfils an important role in the production of purpose-made bends. The usual method employed to develop the templates is often tedious and exposes the finished product to an accumulated error. Some engineering concerns retain templates in the hope that they may be required at some future date, but in view of the infinite number of combinations possible of diameter, angles, and throat radii, it is a somewhat uneconomic task.

The technical chart illustrated in Fig. 1, approximately one quarter full size, presents over 150,000 different bend templates covering a range of bend diameters from 3 in. to 48 in. with throat radius/bend diameter ratios from $\frac{1}{4}$ to 2, and angles in multiples of $11\frac{1}{4}$ and 15 deg. It has been compiled from carefully calculated results and presents the template with a remarkable degree of accuracy, eliminating many of the time-consuming preliminaries required by more conventional methods.

The use of the chart should be undertaken in the following way :

(1) Determine the bend diameter, angle, and throat radius required.

(2) Calculate number of segments required. (All bends must have a half segment on each end). It will be noted that a 90-deg. bend is made up of five 15-deg. segments and two half-segments, or seven $11\frac{1}{4}$-deg. segments and two half-segments.

(3) The panel of the chart in which the template occurs, should be decided. For instance, a 90-deg. bend with a diameter of 12 in. and a throat radius of 24 in., 21 in., 18 in., 15 in., 12 in., 9 in., 6 in. or 3 in. occurs in panels A and B, the difference being the angle of each segment.

(4) Draw the base line of the segment on the required material, equal in length to the circumference of the bend.

(5) Divide the base line into the predetermined number of graduations, stated on the respective panel. This is made easier by stepping off the distance between the graduation base line and the line marked graduations on each respective panel, for the required bend diameter, and letter as shown in the graduation keys at the bottom of the chart.

(6) Step off on both sides of base line (one side only for half segments). The lengths obtained by putting the divider point on the inter-section of the vertical diameter line, and dotted line of required throat radius, and adjusting them carefully to the inter-section of the same vertical line and appropriate converging line bearing letter reference. Continue this process until template is completed.

(7) The profile of the template can then be obtained by joining the points as shown in the graduation key.

(8) Allowances for overlaps can be added as required.

The original chart is more comprehensive than shown in the illustration, the vertical lines of bend diameters being graduated in sixteenths of an inch. A circumference table for diameters from 3 to 48 in. in increments of $\frac{1}{16}$ in. is also included to assist in assessing the base-line dimensions of each segment.

Sample Table to Determine Line for Throat Radius/Bend Diameter Ratio

Throat Radius (in.)	Bend Dia. (in.)	Line Required (ratio)
3	12	$\frac{1}{4}$
6	12	$\frac{1}{2}$
6	8	$\frac{3}{4}$
6	6	1
5	4	$1\frac{1}{4}$
6	4	$1\frac{1}{2}$
12	6	2

* * *

Copies of the complete chart referred to above, and shown in abbreviated form on the facing page, together with the circumference table, may be obtained (price 7s. 6d.) from:

P. G. WILSON,
5, WINCHESTER WALK,
WOODLANDS PARK,
WIDEOPEN,
NEWCASTLE-UPON-TYNE

* The chart is copyright (1959) by P. G. Wilson.

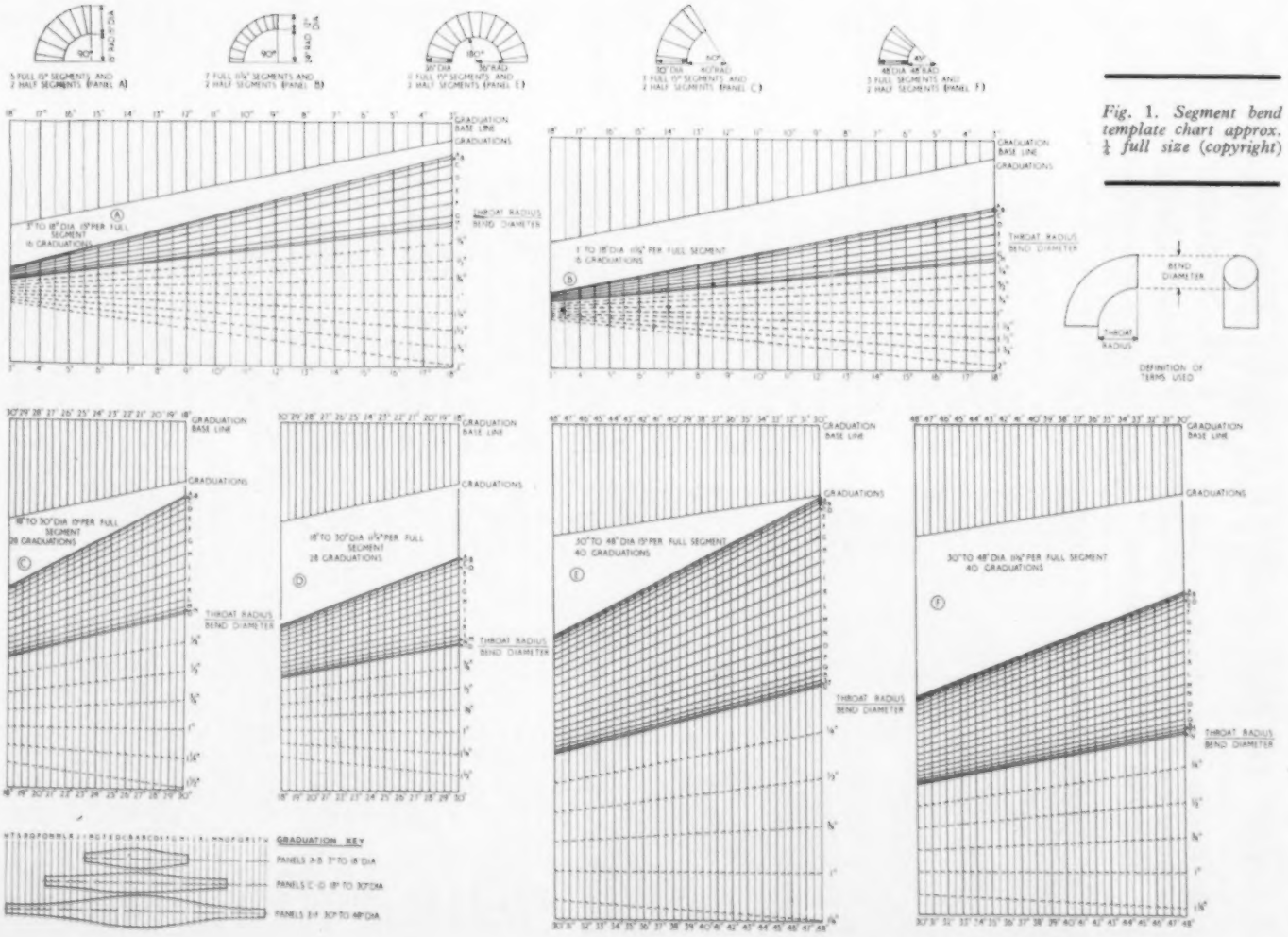
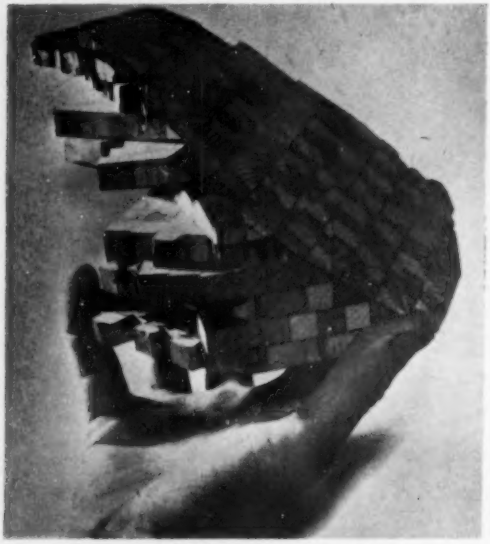

5 FULL 15° SEGMENTS AND 2 HALF SEGMENTS (PANEL A)
7 FULL 11½° SEGMENTS AND 2 HALF SEGMENTS (PANEL B)
2 FULL 15° SEGMENTS AND 2 HALF SEGMENTS (PANEL C)
3 FULL SEGMENTS AND 2 HALF SEGMENTS (PANEL F)
GRADUATION BASE LINE
GRADUATIONS
THROAT RADIUS
BEND DIAMETER
A
3" TO 18" DIA 15° PER FULL SEGMENT 16 GRADUATIONS
B
3" TO 18" DIA 11½° PER FULL SEGMENT 16 GRADUATIONS
BEND DIAMETER
THROAT RADIUS
DEFINITION OF TERMS USED
C
18" TO 30" DIA 15° PER FULL SEGMENT 28 GRADUATIONS
D
18" TO 30" DIA 11½° PER FULL SEGMENT 28 GRADUATIONS
E
30" TO 48" DIA 15° PER FULL SEGMENT 40 GRADUATIONS
F
30" TO 48" DIA 11½° PER FULL SEGMENT 40 GRADUATIONS
GRADUATION KEY
PANELS A-B 3" TO 18" DIA
PANELS C-D 18" TO 30" DIA
PANELS E-F 30" TO 48" DIA

Fig. 1. Segment bend template chart approx. ¼ full size (copyright)

Letter to the Editor

"Grain Size—Its Measurement and Significance in Relation to Cold Rolling"



Method of building up large wooden cube

SIR,—In the discussion to the paper "Grain-Size—Its Measurement and Significance in Relation to Cold Rolling," by V. L. James, published in March, 1960 of SHEET METAL INDUSTRIES," Fig. 13 on page 200 is a full-size photograph of a section of a large wooden cube which was built up from several thousand pieces of centimetre cubes, as shown above.

The object of building up and sectioning such a large cube was to demonstrate the difficulty of determining true grain-size and shape from a cross-section.

The method of construction was as follows. A number of one-centimetre-square wooden rods was glued together to make a board one centimetre thick. This was then cut at right-angles to give a number of one-centimetre-square rods which, of course, were built up from one-centimetre cubes. These rods were then glued together at random to give boards one centimetre thick. A number of these boards were then glued together at random one on top of the other and finally sectioned at random.

Gillette Industries Ltd., Reading. Yours, etc., J. F. KAYSER.

Main Equipment for R.T.B. Spencer Works Now Ordered

RICHARD THOMAS AND BALDWINS LTD. announce that contracts for practically all the main installations at the Spencer Works have been awarded.

The Spencer Works in the initial stages will be planned to produce 1,400,000 tons of steel ingots a year of which nearly all will be rolled at the Works into light plates and cold-reduced sheets; a small tonnage of slabs, however, will be sent to the company's Ebbw Vale Works for processing there into sheets and tinplate.

It is estimated that this first stage of development, which will give employment to between 5,000 and 6,000 people, will begin to come into production towards the end of 1961.

Some details of the plant are as follows :—

There will be two batteries of coke ovens comprising in all 140 ovens, together with the usual by-products recovery plant.

The ore-preparation plant will include a 2-strand sinter plant in which the iron ores will be specially treated before charging into the blast furnaces.

The blast-furnace installation will comprise two blast furnaces, each of approx. 30-ft. hearth diameter, six hot-blast stoves and appropriate blowing equipment and gas-cleaning plant.

As previously announced, RTB have signed a licensing agreement with Brassert Oxygen Technik A.G. of Zurich for the operation of the L.D. process of steelmaking. This method of steelmaking will be used at Spencer Works.

Twenty-two soaking pits will be installed to reheat the ingots before rolling in a universal slabbing mill of the latest design.

The 68-in. continuous hot strip mill will be equipped with two large slab reheating furnaces, the usual scale breakers and roughing mills, a 6-stand tandem finishing train, and two down-coilers. Part of the output will be processed in the hot sheet-finishing department, but the bulk will be sent forward for cold reduction.

A continuous pickling line, complete with acid-recovery plant, a 4-stand cold-reduction mill and two temper mills will be the main components in this department. Other equipment will include annealing furnaces believed to be the largest in the country, cut-up lines, and oiling and inspection units.

In all the Spencer Works will produce 1,085,000 tons of hot-rolled coil, of which 805,000 tons will be cold reduced, giving an output per year of 710,000 tons of cold-rolled sheets.

SHEET METAL DATA SHEET

4

Mechanical Presswork—2

Compiled by J. W. Langton, M.B.E., B.Sc.(Lond.), M.I.Mech.E.

PRESS SELECTION

REMEMBER first that a press has to give its pressure through a certain distance from the bottom of the stroke, and it is therefore essential to know both pressure and this distance (and their product—work done) before the true capacity can be known.

Pressure

The working pressure of a press is given usually by the manufacturer. If it is not known then a *rough* approximation for light mechanical presses can be obtained from

$$\text{Maximum pressure rating} = (P) = \frac{Cd^2}{\text{stroke}}$$

where C is constant and d the crank diameter; C obviously varies with crank design and support, etc. Approximate values of C vary from about 1.8 to 3.0 with 2.5 being a more common figure. Note this is the maximum pressure rating, obtainable only at a short distance (ungeared presses about $\frac{1}{16}$ in., geared presses about $\frac{1}{4}$ in.) from the bottom of the stroke.

The pressures given well away from the bottom of the stroke *fall very considerably*—for example when the crank is at 45 deg. the pressure given could be only $\frac{3}{4}$ of that very near bottom of stroke.

Lesson of this—is that if a certain pressure is necessary say more than $\frac{1}{8}$ from bottom of stroke, then a press must be chosen to give that pressure there.

Work

Work capacity = Pressure capacity × Distance through which pressure is exerted.

i.e., For light *ungeared* presses.

$$\text{Work done} = \frac{\text{Press capacity}}{16} \text{ in.-tons.}$$

A more exact check can be made from the flywheel.

Assuming 10 per cent. speed reduction per cycle the available flywheel energy is given by

$$\text{Useful energy} = 0.000156\ W\ D^2N^2 \text{ (in.-tons)}$$

N = rev. per sec.
D = flywheel diam. in feet
W = wt. flywheel (lb.)

If weight of flywheel is not known, an approximation can be obtained from

$$W = 0.544\ W^2\ (D - \tfrac{3}{4}\ w).$$

D is diam. in inches. W = width of rim in inches. w = wt. (in lb.) of cu. in. of material.

Effect of Gearing

The addition of gearing increases the work capacity but *not* the pressure capacity, *i.e.* a 60-ton press will only give 60 tons pressure if gearing is added, but it will give it through a greater distance from the bottom of the stroke—usually 2 to 4 times the distance.

The pressure capacity is determined from crank and frame dimensions—work capacity from flywheel.

Tie Rods: C-Frame Presses

These fittings should be considered as having no real effect on press tonnage, *i.e.* if fitted to a 60-ton press, then this pressure should not be exceeded because of the tie bars. Properly used, they can help to reduce frame spring.

Press Capacity Selection

The press capacity selection is determined by calculation of pressure and work loads required for any particular job, and a suitable press chosen.

Final Press Selection

Having determined the press capacity consideration must be given to

(*a*) **Most Suitable Type**

Here specially consider feeding and removal of work—need for pressure medium—roll or direct feeds, etc.

(*b*) **Stroke**

Apart from having suitable stroke for the work, consider items like guarding. A small stroke if sufficient can often eliminate need for guard. Guarding is always important.

(*c*) **Linear Dimensions**

As tool space.

Study daylight dimensions carefully—note most are measured from press bed—not bolster.

(*d*) Future possible work required from the press, *i.e.* consider if it is worth while to buy a press with extra capacity in case it is needed later or consider types with double work possibilities (as horn press with table).

(*e*) **Mechanical Details**

Note especially here clutch—the most likely source of trouble—then main bearings as for crank and connexion—connexion itself—the length of ram guides.

Where feeds are fitted so that every stroke is a working stroke and the press is to so run at its top speed, be especially careful about crankshaft and connexion bearings and in such cases the clutch is of less importance.

Blank Determination and Drawing Work

Before drawing operations can be laid out, it is usually necessary to have some fairly close appreciation of the blank size.

Blank Determination for Round Work

Exact blank determination can only be made by trial and error, under exact working conditions. Theoretical calculation can be made for blanks, based usually on the assumptions (1) that shell area and blank areas are equal or (2) that their weights are equal.

Area Basis

To determine the blank for a round component on No. 1 basis above, it is only necessary to equate areas. Example,

4 SHEET METAL DATA SHEET

Mechanical Presswork — 2 (Cont.)

for round shell, mean diameter d, height h—top corner sharp—blank diameter required D.

Area blank $= 0.7854\ D^2$.

Area shell $= 0.7854\ d^2 + 3.14\ dh$.

Equating $D = \sqrt{(d^2 + 4\ dh)}$.

In practice the shell is not sharp cornered, so the above blank will be too large. If r is corner radius of top of shell, and the area calculated accordingly, we would have

$$D = \sqrt{(d^2 + 4\ dh - 1.72\ rd)}.$$

For other cases, it is simply a matter of figuratively splitting up the shell into parts for which the areas can be easily calculated, adding them up and equating to blank area.

Weight Basis

A value for the blank size can be obtained from the ollowing:

$$D = 1.13 \sqrt{\frac{W}{w\ T}}.$$

where W is weight of component (lb.), w is weight (in lb.) of cu. in. of material and T is stock thickness.

Blank Determination for Rectangular Work

In such cases, it can be assumed that at the four corners there are portions of a cylinder being drawn, with pure bending at the sides.

To find the approximate blank for a shell say length l, width b, and height h, corner radius r. On main centre lines mark off a rectangle

$(l + 2h - 0.86\ r)$ by $(b + 2h - 0.86\ r)$.

Using cylindrical formulae $D = \sqrt{(d^2 + 4\ dh)}$ calculate D where $d = 2r$. (If corner radii at base of shell is large use the alternative formulae).

Then with radius $\frac{D}{2}$ centres, shell corner radii centres, mark arcs at the four corners which indicate minimum points at blank corners. These arcs must then be joined to the outer rectangle, by smooth curves. The form of these curves varies according to relationship between h and r, and they cannot be estimated reliably. However, with the minimum points established, trial and error should soon determine the final form.

Blank Determination—Oval Work

First, with regard to the shape of the oval itself. An approximate method for drawing an oval is as follows. On centre lines mark off major and minor axes. MN and LP (see Fig. 1). Join LM, and with L as centre and with radius half minor axes (OL) mark off on LM—distance LR. Bisect RM at right-angles and produce bisector to meet horizontal centre-line at A and vertical centre line at B. Then with A as centre, radius AM draw an arc, and repeat process at the opposite side so that a similar arc passes through N. With B as centre, and radius BL draw joining arc to meet end arcs and repeat to have joining arc similarly passing through P.

If the oval shape is established using the above construction, it will help in the subsequent tool manufacture. Some of the machining of the die parts can then be turned instead of milled, saving real time. When making the blank template, the circular formulae can be applied, on the assumption that in the oval, there is being drawn parts of four cylindrical shells. To make this quite clear:

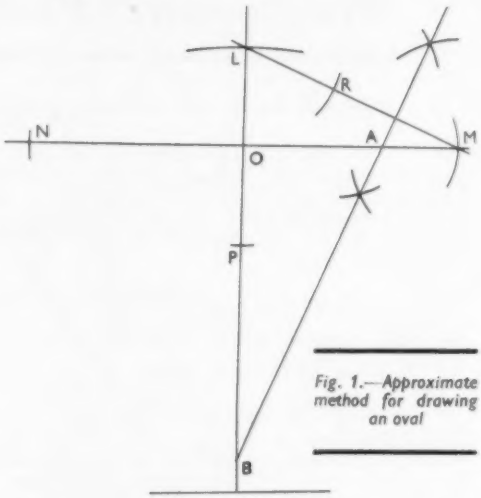


Fig. 1.—Approximate method for drawing an oval

at the ends we have virtually drawn parts of a cylinder whose diameter is 2 × AM and depth say h. If there is no flange on the pressing, we would use

$$D = \sqrt{(d^2 + 4\ dh - 1.72\ r.d.)}$$

where $d = 2 \times$ AM and r is top corner radius. When this is worked out, the end approximate blank curves are drawn with centre A and radius D/2. The process is repeated for the sides where $d = 2 \times$ BL.

Drawing Work (Cylindrical)

Each example has really to be considered in its particular drawing circumstances, but the following is a rough guide:

$$\text{Diameter of first operation} = \frac{\text{Blank diameter.}}{1.6 \text{ to } 1.8}$$

Subsequent reductions can be of the order of 25 to 40 per cent. It is assumed pressure medium used gives approximate constant pressure.

The approximate drawing pressure (including for blank-holder pressure) is given by

$$\text{Working drawing pressure} = \frac{16}{15} \text{ Pressure to shear out base,}$$

and Pressure to shear out base = Perimeter of base × stock thickness × shear stress.

Work done in drawing = Working drawing pressure × shell height.

Drawing Work (Rectangles)

Here the drawing conditions are very complex and it is quite impossible in this space to give all the background data. The maximum depth of draw in one operation is largely dependent on the corner radius. Very *rough* guides as to possibilities are given by

For radii up to $\frac{2}{16}$ maximum depth $= 5\ r$

For radii about $\frac{1}{8}$ to $\frac{3}{4}$ maximum depth—$4\ r$.

Where say two operations are involved, rough radius of first die corners is approximately $4\ r$, but *not* on same centre—this centre arranged to give satisfactory width in draw ring.

SHEET METAL NEWS

FEATURING EVENTS AND PERSONALITIES IN THE INDUSTRY

SHEET-METAL FORMING AND METHODS OF TESTING

Joint International Colloquium to be held in Paris

AS previously announced a colloquium on sheet-metal forming with special emphasis on methods of testing, organized jointly by the Société Français de Métallurgie and the International Deep Drawing Research Group, will be held in Paris from May 23 to 27, 1960, inclusive. The first three days of this meeting will be devoted to open sessions at which papers will be presented and discussed on Theoretical Studies of Sheet Metal Forming, Methods of Sheet Metal Testing, and New Techniques of Sheet Metal Forming. The final day will be taken up with closed meetings between delegates of member bodies of the I.D.D.R.G. (in the case of the U.K. the member body is the Institute of Sheet Metal Engineering) at which the programme of investigational work for the ensuing year will be drafted.

Registration

There will be a registration fee for attendance at the Colloquium of 60 New Francs, but no fee will be paid by authors of papers. Registrations should be addressed to : The Secretary, Société Française de Métallurgie, 25, rue de Clichy, Paris, 9eme.

The closing date for the receipt of registrations is April 30.

General Arrangements

The working sessions will be held in the Conference Room of the Association of Automobile Builders (Le Chambre Syndicale des Constructeurs d'Automobiles), 2, rue de Presbourg, Paris (8eme) (Etoile district).

There will be a reception on Tuesday evening, May 24, at 6 p.m. in Latin American House (La Maison de l'Amerique Latine), 96, Avenue d'Iena, which is close to the Conference Room.

PROGRAMME

Monday, May 23, 10 a.m.

Opening of the Colloquium, by Mons. H. de Leiris, President of the S.F.M.

Introductory lecture by Drr. G. de Witte, President of I.D.D.R.G.

1st TECHNICAL SESSION.

ANISOTROPY.

" Influence de l'Anisitropie des Toles sur la Deformation Plastique en Sollicitations Uni-et Biaxiales " par C. Crussard, G. Pomey, D. Lajeunesse.

" Drawability and Anisotropy in Metal," by R. L. Whiteley.

Monday, May 23, 2.30 p.m.

2nd TECHNICAL SESSION.

FUNDAMENTAL STUDIES.

" Classification and Systemization of Sheet Metal Press Forming Processes," by K. Yoshida.

" Le Formage des Toles Minces a Froid " pas J. Guyot.

" The Assessment of the Formability of Sheet Metal by Cupping Tests and from the Stress Characteristics," by J. F. Wallace.

" A New Tensile Flow-Curve for Plane Strain," by K. Takase.

" Untersuchung des Formziehens Komplizierter Hohlteile " von A. Tomlenov.

" Evaluation of Drawing Properties of Sheet Metal," by L. A. Rubenkova.

Tuesday, May 24, 9 a.m.

3rd TECHNICAL SESSION.

THE SWIFT TEST.

" An Investigation of Swift Cupping Test Correlation and the Influence of Tool and Material Surface Finish on the Test Results," by P. W. Whitton and D. R. Mear.

" Investigations on the Swift Cupping Test," by J. H. Zaat.

" The Study of Strain Age Hardening of Rimming Steel Using the Swift Cupping Test and the Influence of Punch Shape on the Results," by D. K. O. Ullmann.

" The Usefulness of the Tensile and the Cup-forming Test when Testing Aluminium Sheets for Deep Drawing," by C. R. Vassel.

4th TECHNICAL SESSION.

CUP FORMING TESTS.

" A Stretch-Forming Test for Using with a Variable Speed Cupping-Press," by D. V. Wilson, B.B. Moreton and R. D. Butler.

"Einfluss der Werkstoffeigenschaften und Prufbedingungen auf die Ergebnisse des Napfchen-Ziehversuchs " von W. Panknin.

Tuesday, May 24, 2.30 p.m.

5th TECHICAL SESSION.

THE ERICHSEN TEST.

" Influence de Quelques Facteurs sur les Resultats de l'Essai Erichsen " par M. Jentet.

" Remarks on the Erichsen Drawing Test," by Di Bartolo.

" Vergleichende Untersuchungen Über die Ergebnisse der Tiefungsprufung mit dem Näpfchenziehversuch und mit dem Erichsen-Versuch an Weichen Stählen " von A. Kruger.

6th TECHNICAL SESSION.

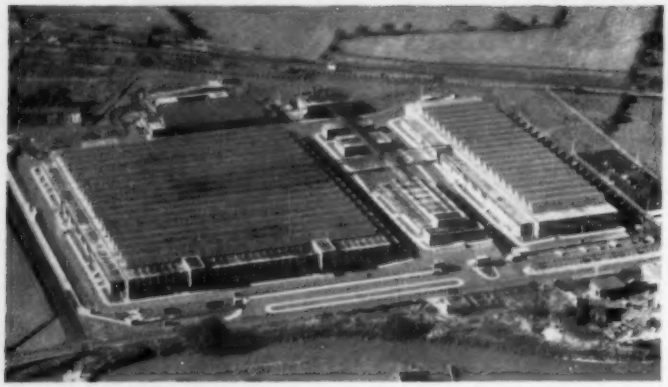
MISCELLANEOUS TESTING PROCEDURES.

" The Correlation Between Experimental Value Obtained by Various Drawability Tests," by S. Fukui, K. Yoshida and K. Abe.

" Recherches sur les Essais d'Emboutissabilite " par J. Pomey, A. Royez and P. Dhez.

" Mise au Point d'un Embouti Type Representatif des Pieces de Carrosserie," by M. Jentet.

(*Continued in page* 298)



GAS IN TUBE AND VALVE *Works at*

A VISIT to the Simonstone and Blackburn works of Mullard Ltd. was arranged recently for the technical press by the Gas Council and the North Western Gas Board.

Between them, the Mullard plants in Lancashire use about 1.8 million therms of town gas a year, the biggest single gas-consuming units being the Lehr furnaces at Simonstone through which television tubes pass in order to drive off moisture, etc.

It is difficult to visualize the method of producing TV tubes and radio valves that would be adopted if gas were not available, and it should be realized that tolerances on the glass envelopes and particularly on the electrode systems (produced by drawing, forming and welding operations on e.g. thin gas-free nickel) are very close.

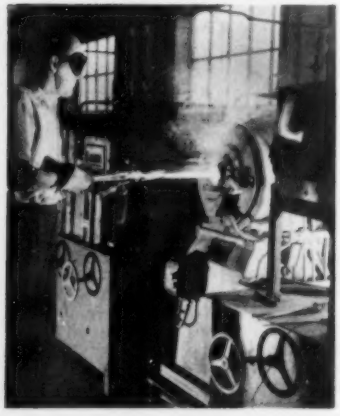
Simonstone Works

The production of television tubes at Simonstone begins with the component parts of the glass bulb; the cylindrical neck, the flared cone, and the rectangular face-plate.

First, the neck is welded to the cone in automatic rotary machines, of which there are six in the plant, each having 12 stations. The two parts are first preheated by radiant-cup gas burners and gas-air burners to bring them to the correct temperature for welding and the weld is then made by oxy-coal gas jets. Following this the bulbs are transferred to a side sealing machine where the metal e.h.t. connexion is fused into the side of the cone. The region of the seal is preheated by radiant cup burners and gas-air jets, and the seal is made by oxy-coal gas jets.

The neck and cone assembly is then annealed and preheated ready for the faceplate to be joined on; the faceplate is also preheated to the same temperature. Twenty-four automatic machines weld faceplates to the neck and cone assemblies. Gas-air jets preheat the two component parts, and cross-fires of oxy-coal gas jets further raise the temperature of the welding region. The actual weld is accomplished by an electric arc struck through gas flames which brings the edges of the two components up to melting point, when a perfect seal takes place. The gas jets automatically follow the contour of the faceplate keeping a constant distance from the glass as it rotates. The complete bulb is annealed and allowed to cool slowly. The bulbs are now introduced to the two-mile long overhead conveyor system that runs through the entire plant, and around which all the subsequent processes are planned.

The cooled bulbs are thoroughly washed with different solutions, finishing with purified water, to make ready for the vital process of laying the fluorescent screen, effected in rotary mills which are fitted with dispensers which automatically deliver the correct amount of buffer solution, water-glass and fluorescent powder. The fluorescent powder gradually settles down through the buffer solution evenly



(Above).—View of Simonstone factory of Mullard Ltd.

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(Left).—Typical swaging operation of sintered bars for wire drawing

●

(Right).—Intermediate wire drawing operation

TELEVISION-RADIO-PRODUCTION

Practice

Mullard Ltd.

on to the surface of the glass, where it is held by a gel-like formation produced from the different solutions. The bulbs are automatically tilted to remove the liquid, leaving the screen deposit undisturbed. The bulbs are dried by infra-red lamps and filtered air and are then given internal coatings of lacquer and graphite, the latter to form an electrical connexion between the final anode and the e.h.t. connector.

The bulb is then ready for laying a film of aluminium by vacuum deposition on the inside of the screen and cone.

The bulbs are next passed slowly through one of two continuously operated 100-ft. long Lehr furnaces to drive off all moisture and to bake out the unwanted constituents of the various coatings, which would otherwise make it impossible to maintain the necessary vacuum in the finished tube. This baking process also fixes the fluorescent screen firmly to the glass face.

The electron guns are assembled in a separate part of the factory by highly trained female operators. The component parts (over 60 to each gun) are manufactured to extremely high standards of accuracy and a system of statistical quality control is applied throughout so that there is no possibility of faulty parts reaching the assembly operation. Oxy-coal gas jets are used in the assembly of the guns, to weld the glass support rods in the electrode assembly.

The sealing machines for sealing the gun into the neck have 12 stations and employ radiant cup gas burners for preheating the region of the join and oxy-coal gas jets for the actual seal.

After this operation the tubes are evacuated, during which the tube passes through a long heated tunnel. This heating process drives off any gases present in the metal electrodes, the glass blub, or the screen materials. At the same time, an electric current is passed through the heater to give the cathode the necessary emissive properties. These operations completed, the getter is "fired" by induced high-frequency currents.

The tube is now connected to power supplies and its internal metal components are bombarded by electrons from the cathode to stabilize its performance, and it is then subjected to a series of rigorous tests.

Blackburn Works

The major part of the Blackburn plant is engaged in the manufacture of receiving valves, chiefly for radio and television. Apart from the mica spacers and the nickel used for some electrodes, all the components for the many different types produced are made within the plant from the raw materials.

The basic components of a valve are: the electrodes, comprising heater, cathode, anode and, excepting diodes, one or more grids; the glass envelope and base; the internal supporting members, mica spacers and insulators. These various component parts are fabricated in separate units of the plant and brought together in the assembly bays where skilled operators build up the complete valves.

The cathode of the valve, the electrode that provides the emission of electrons, consists of a central core of nickel tube, round which the emissive coating is sprayed. The

(*Continued in page* 300)

(*Above*).—*View of Blackburn factory of Mullard Ltd.*

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(*Left*).—*Welding electrode cage on to valve base*

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(*Right*).—*Special machine for welding 3-piece connecting wires which pass through glass base*

Mullard Ltd.

(*Continued from page 299*)

nickel tubing is re-drawn in the plant's wire drawing unit to the very small dimensions required in cathodes, which may scale only 0.75 mm. by 0.65 mm., with a wall thickness of 0.05 mm. The emissive coating, a mixture of barium and strontium carbonates in a volatile solvent, is sprayed on under careful control to ensure a coating of uniform density and thickness. Inside the central tube of the cathode is inserted the heater, or filament. This consists of a spiral of very fine tungsten wire formed into a " V " or " M " shape and coated with aluminium oxide to insulate it electrically from the cathode.

The grids of the valves are essentially flattened spirals of very fine molybdenum wire wound on stiff " backbones " or supporting rods. They are wound automatically on precision winding machines in lengths of about 4 ft. at a time, and each length is then cut into individual grids of appropriate size.

Anodes are pressed to the required shape and size by automatic machines from nickel, nickel-plated steel or aluminized steel depending on the type of valve.

In the assembly bays operators, assisted by ingenious mechanical aids, assemble the electrodes into a " cage " ready to be mounted on the base. The base is a small disc of glass holding the connecting pins by which the valve plugs in to the valveholder and a corresponding number of wires to which the various electrodes are connected. Joining the stiff metal pins and the thinner connecting wires is a third length of wire which has the same overall coefficient of expansion as the glass, and which, therefore, ensures a perfect airtight seal where the wires pass through the glass.

The machines that make the bases automatically feed the correct number of tri-metal connecting wires into a jig. A collar of glass is placed round the wires and the whole assembly is revolved. As it rotates, gas flames soften the glass collar and the machine gently presses it into shape around the centre sections of the tri-metal wires. Special machines then cut the connecting wires into the right lengths and bond them to the exact positions for the electrodes to be welded to them.

Once the electrode cage has been joined to the base, the next steps are to seal the assembly into its glass envelope and then to evacuate the air to form the vacuum necessary to the operation of the valve. Substantial quantities of gas are used in these operations. In the first, gas jets are employed to soften the glass at the junction of the base and the envelope before the sealing machine automatically applies the correct pressure to form the joint; and in the second for pinching off the pumping stem once the air has been removed.

While the valve is being pumped, the metal components inside are heated by induced high-frequency currents to drive out any gases which have been absorbed during manufacture. A current is passed through the heater to reduce the cathode coating to oxide, thus forming the electron emitting surface, and induced heat is again used to evaporate the getter to absorb the last traces of gas. When the valve has been removed from the machine it is operated for a period under controlled conditions. During this period changes occur in the cathode coating resulting in improved emission.

Finally, the valve is put through a succession of exacting tests covering its operating characteristics, emission vacuum, insulation and so on.

Making Fine Wire

A large section of the Blackburn works is given over to the manufacture of tungsten and molybdenum wire. Much of this appears as grids and filaments in the millions of valves produced each year by the plant. But a substantial amount is supplied to other manufacturing industries for a variety of purposes.

The annual output of wire exceeds a quarter of a million miles; the finest wire has a diameter of 5 *thousandths of a millimetre*.

Tungsten occurs naturally in the tungstates of iron, magnesium and calcium. It is the latter, known as scheelite, that is used at Blackburn. The quality of scheelite available from various world sources varies greatly, and skill and experience are necessary in its selection. Molybdenum is obtained from molybdenite ore, the chief deposits of which are in the American continent, Norway and Yugoslavia.

For tungsten wire, the scheelite ore is put through chemical tests to ensure its quality, after which it is ground continuously for several days in a ball mill. The resulting very fine tungsten oxide powder is purified chemically, and placed in reducing furnaces where, in a hydrogen atmosphere, it is converted to tungsten metal powder. The reducing furnaces, which run up to 900° C., are gas burning. Controlled amounts of special additives are introduced into the pure powder to control its crystal structure and to prevent the finished wire sagging, and the powder is then compressed into bars of convenient size.

Next come sintering processes which crystallize the compressed powder into a hard metal, ready to be made into wire. Sintering is done by first heating the bars in an atmosphere of hydrogen and then passing through them an electric current of between two and three thousand amperes.

The sintered bars are swaged by raising them to white heat, then hammering in successive stages until they take the form of thin rods. Gas furnaces are used to heat the bars prior to hammering.

The tungsten rods are drawn through a series of progressively smaller dies until they have been reduced to the thickness required. Drawing occurs in three main stages: First, on a chain bench, next on large diameter drums, and finally on smaller drawing heads. In each stage a number of dies are used, carefully spaced to achieve a gradual reduction in diameter and, at the same time, to increase the strength and ductility of the wire. Hard metal dies are used in the initial stages, but as the wire becomes thinner diamond dies are necessary. Gas is used extensively throughout the drawing operations, for heating the wire before it is pulled through the dies and also in the annealing furnaces through which the wire passes at predetermined intervals to remove strains.

Once the required diameter has been obtained the wire is put through a series of strict tests and inspections to check its dimensional accuracy and mechanical properties. Often it is so fine that its diameter can be measured only by accurately weighing it against a standard length.

TUNGSTEN-ARC CUTTING PROCESS

BRITISH Oxygen Gases Ltd., who have undertaken development work in the United Kingdom in the above process, are now marketing the equipment in arrangement with Union Carbide Ltd.

The tungsten-arc cutting process was originally developed by the Linde Company of the Union Carbide Corporation for form-cutting readily oxidized metals, such as alminium, stainless steel, titanium and copper. The process depends upon a non-consumable electrode working in a gas stream and cuts these metals at a high rate. The cut edge is metallurgically clean, free from contamination and requires a minimum of preparation for welding or constructional assembly.

NEW BRITISH DOUBLE-ACTION DRAWING PRESS

WILKINS AND MITCHELL LTD., Darlaston, manufacturers of the double-action drawing press referred to in our March issue, have pointed out that by their system of nomenclature the press should have been called a "1,000-ton press," this being the total capacity of the draw slide (600 tons) and the blankholder (400 tons).

British Licencees for U.S.A. Shotblast Equipment

THE Hepburn Conveyor Co. Ltd. announce that they are the sole licencees for the manufacture of Pangborn equipment in the U.K. and for its distribution throughout the majority of the Commonwealth and some other countries.

Sheet Metal Forming

(*Continued from page* 297)

Wednesday, May 25, 9 a.m.

7th TECHNICAL SESSION.

MISCELLANEOUS PROCEDURES.

"L'Essai KWL" par L. Mazet.

"La Determination des Possibilities d'Emboutissage Cylindrique des Alliages Legers" par R. Chopin.

"Fehlteile als Folge von Blechdickenabweichungen" von G. Oehler.

8th TECHNICAL SESSION.

MISCELLANEOUS STUDIES.

"The Problem of Elaborating the Method of Testing to Appraise the Capacity of Sheet Steel for Deep Drawing," by B. M. Ovsyannikov.

"Die Hydraulische Tiefungsprufung zue Aufnahme von Fliesskurven und zur Ermittlung der Relativen Verfestigung" von W. Panknin.

"Examen de la Deformation des Pieces Embouties en Toles ou en Feuillard Mince" par Ch. Caillot.

Wednesday, May 25, 2.30 p.m.

9th TECHNICAL SESSION.

NEW TECHNIQUES.

"Formability of Sheet Metal Under Multistage Drawing," by Noricyn.

"Double Action Hydroforming Process," by S. Fukui, K. Yoshida and K. Abe.

"The Application of Phase Change Lubrication to Stretch-Forming," by J. F. Wallace.

"Explosive Metal Forming," by Zernov.

Summing up of the Colloquium, by Professor O. Svahn.

Closure of the Colloquium, by Drs. G. de Witte, President of the I.D.D.R.G.

WELDING DEMONSTRATION WORKSHOP

MERITUS (Barnet) Ltd., have opened a welding demonstration workshop at their factory at Barnet, Herts. A comprehensive range of their welding machines can be seen and demonstrated at any time, including Saturdays, by appointment.

Russian Order for British Tools

AN order from the Russian Trade Delegation covering precision machine tools to the approximate value of £200,000 has been given to the Coventry Gauge and Tool Co. Ltd.

TRADE WITH THE SOVIET BLOC AND CHINA

Revised List of Goods Subject to Embargo

THE Board of Trade Journal has published a comprehensive and up-to-date list of goods subject to strategic embargo. The new list makes a number of routine changes not hitherto announced. Four items have been deleted (milling machines for aircraft spars, germanium, cobalt compounds, and petroleum-based hydraulic fluids). Relaxations have been introduced in several items, including steel-works plant, certain electronic equipment and transistors. At the same time, the embargo now includes some narrow ranges of specialized strategic equipment not hithero covered.

TWIN-SPOT WELDING

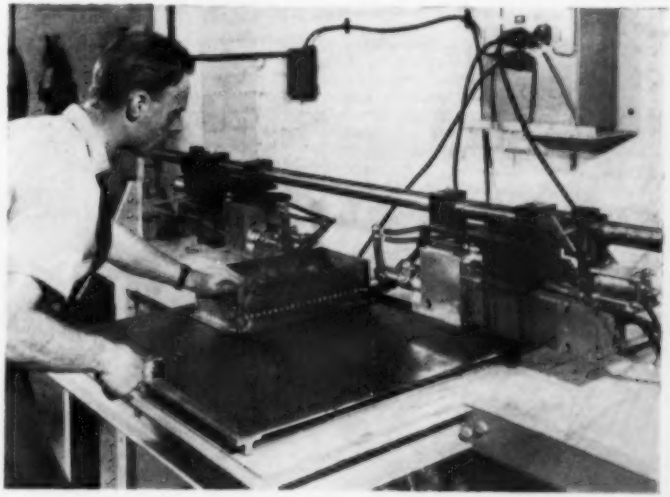
THE A.R.O. Machinery Co. Ltd. have now released details of a special double twin-spot welding application used in the manufacture of ventilating grilles, the complete welding equipment being designed and manufactured by A.R.O. and the tooling and feeding table being by Thomas McDowell Ltd.

The machine, which is installed at the Wembley works of Thomas McDowell Ltd. consists of a fabricated mild-steel frame on the top of which is a steel traverse rod on which two A.R.O. type DP.47 air-operated twin-spot gun units are mounted.

The height of this traverse rod in relation to the operating height of the weld line can be rapidly adjusted by means of hand-operated cams at each end of the machine, enabling the lines of welds to be varied with respect to the feeding table height.

The right-hand twin-spot unit can be indexed across the horizontal traverse rod and locked into position to suit many widths of grille assemblies. The operation consists of welding mild steel pivots on mild steel cases to enable louvre plates to be retained in position within the cases. These are then fed between the electrodes of the opposing fully-controlled transformer/gun units, both guns moving simultaneously into contact and making four welds at every operation.

Production speeds are in the order of 6,750 welds per hour.



U.S.A.'S FIRST RECTIFIER-SYSTEM POWERED STEEL MILL

A NEW steel mill with a 12-million pound "bite" has been put into operation at the Lukens Steel Company's Pennsylvania (U.S.A.) plant. The 140-in. plate mill is the first major reversing mill in the United States to be powered by a static power supply, an 8,000-kilowatt rectifier system.

The rectifier, a static power source which converts incoming alternating current to direct current to power the drives, was specially designed for Lukens Steel by U.S. General Electric.

Maximum separating, or reduction, force of the mill is 12-million pounds, enough to squeeze a 60,000-pound 30-in. ingot of heavy carbon steel into a 10-in. slab in less than two minutes. About every four seconds a pass of the ingot is made through the giant rolls. The 10,000-h.p. main drive generates "pull" equal to that of 25 diesel-electric freight locomotives.

Despite its size and power, the mill responds to fingertip control. The main drive can be reversed from normal forward speed to reverse speed in one-and-a-half seconds. The opening between the huge rolls can be adjusted as little as one- one-hundredth of an inch, roughly the thickness of a tin can.

Completion of the mill was part of a two-year £10 million expansion programme that has boosted Lukens into third place among America's steel plate producers.

BRITISH AGENCY FOR ITALIAN MILL

LANCING Machine Tools Ltd. announce that they have been appointed Sole Agents in the United Kingdom for Boldrini, S.p.A., of Milan. Boldrini plate and section working machines are well-known in Continental shipyards and heavy engineering works, and the range includes pyramid and pinch-type bending rolls up to 20 ft. wide, shipyard rolls up to 40 ft. wide, plate straightening rolls up to 13 ft. wide, rotary cold-flanging machines for flat and dished ends for plates up to 16 ft. 8 in. diameter and ¾ in. thick, friction screw dishing presses, roller-type machines for shearing and pre-bending both edges of plates preparatory to rolling in pyramid rolls, roller-type joggling machines, angle-ring and section-curving machines and pipe-bending machines.

The latest design of Boldrini pinch rolls incorporates British Patent No. 740,498 which gives advantages in reduction of the residual flat over the other types of rolls.

U.K. FIRM TO MANUFACTURE AMERICAN EQUIPMENT

SIR GRAHAM CUNNINGHAM, K.B.E., chairman of Weldall and Assembly Ltd., has announced that an agreement has been concluded between the company and Fried Steel Equipment Manufacturing Corporation of New York. Licencing arrangements have been granted to Weldall and Assembly Ltd., one of the largest steel fabricators and conveyor specialists in Great Britain (and a member of the Triplex Safety Glass Group) who will manufacture and sell Fried units on a world wide basis with the exception of the Americas and Canada.

Fried Steel Equipment, designers and manufacturers of material handling equipment have developed and patented the Fried Stripveyor, Fried Liftveyor and Fried Strip Stacker, highly specialized material-handling equipment for sheet and plate squaring shears.

AGREEMENT ON NON-DESTRUCTIVE TEST EQUIPMENT

AN agreement has been concluded between Kelvin and Hughes Ltd. and the Curtiss-Wright Corp. of America for the exclusive right to manufacture and sell the non-destructive testing equipment of the other partner. This includes instruments for the inspection and measurement of materials, and equipment employing ultrasonic techniques in all industrial fields.

The agreement covers certain defined territories. Kelvin and Hughes will represent both interests in the U.K., the Commonwealth (except Canada) and Europe, and Curtiss-Wright in the U.S.A. and Northern America.

Each party to the agreement will offer full sales and service facilities on the joint range of equipment.

Kelvin and Hughes have developed a range of manual, semi-automatic and automatic ultrasonic test equipment. Curtiss-Wright also manufacture ultrasonic equipment but has, in addition, a range of industrial radiographical equipment using X-ray and Gamma ray techniques.

CHANGE OF ADDRESS

The new address of Aerox Ltd. is Chalford, Stroud, Glos. The floor space in this new factory is five times greater than that in the old.

NEW PREMISES FOR STEIN AND ATKINSON LTD.

TO provide the working conditions needed to deal with their greatly expanding business of designers and builders of furnaces and heat-treatment plant for the steel and glass industries, Stein and Atkinson Ltd. have had a four-storey block of offices built to their special requirements. All engineering and administrative departments are now accommodated at Westminster House, Kew Road, Richmond, Surrey, adjoining Richmond Station.

MULTI-MILLION POUND SOUTH AFRICAN MOTOR PROJECT

IN order to achieve a much larger South African participation in the production of motor parts, a vast project has been launched by an agreement between Vecor (Vanderbilj Engineering Corporation Ltd., Vanderbijlpark, South Africa) and Rubery, Owen and Co. Ltd., Darlaston, England, for the manufacture in the Union of wheels, axle housings, petrol tanks, chassis frames, body pressings and other motor-vehicle components.

Rubery, Owen and Co. Ltd., the parent firm in the Owen Organization, a group of 46 companies most of them in engineering, is already one of the largest manufacturers of wheels, axle cases, chassis frames, and other motor vehicle components in Great Britain.

The Owen Organization has for some time been considering the establishment of a motor vehicle component manufacturing plant in South Africa, and to this end Mr. A. G. B. Owen and senior technical executives of the Owen Organization have recently visited the Union.

The company in addition to their very considerable financial investment in this new project are contributing design work, tooling and know-how from their unrivalled resources in this direction.

Vecor was founded in 1947 by the South African Iron and Steel Industrial Corporation Ltd. in association with other large industrial and financial organizations, and today has the most up to date pattern shop, foundry, fabrication, forging and machine shops. Vecor's engineering reputation is unrivalled in the Union. Its subsidiary, Metal Pressings Ltd. is the largest producer of drop forgings and pressings and has already reached agreement with certain motor assemblers in the Union for the supply of wheels and other components.

The fact that the Owen Organization and Vecor are now co-operating in this field will undoubtedly ensure the successful response to South African government policy to expand the use of Union made motor components.

COLD ROLLED CHESSMEN

A COMPLETE set of chessmen each 2 ft. high, made out of cold-rolled strip steel and standing on a large chess board, was the main feature of the Guest, Keen and Nettlefolds Group stand at the Leipzig International Trade Fair.

The stand also showed a number of well-known Group products.

RECTIFIERS FOR WELSH TINPLATE EXPANSION

AN order valued at more than £200,000 has been received by the Associated Electrical Industries Ltd. Heavy Plant Division from the Tinplate Division of The Steel Company of Wales for germanium rectifiers for a third tinning line at the company's Trostre Works, Llanelly. The equipment, which will consist of five large groups of rectifiers, will be used for the cleaning, pickling, tinning, and chemical treatment of strip in a range of widths from 27 in. to 38 in., and thicknesses from 0.006 in. to 0.015 in. The total capacity of the installation will be approximately 4,000 kW. and the aggregate current more than 200,000 amp. at voltages up to 24.

The two largest groups of rectifiers will be used for the tinning operation. Saturable reactors provide independent control of the output of the rectifiers to each side of the strip, and in this way the application of the tin can be controlled. For canning purposes, tinplate needs a heavier coating of tin on one side (the inside of the can) than the other, so during the tinning process the output of the rectifiers is adjusted to take this requirement into account. Air-cooling is used, heat exchangers supplying cooled air to the germanium cells in an enclosed forced-ventilation system. McLellan and Partners are the consulting engineers.

American Electronics Firm Opens English Plant

A LEADING American manufacturer of electronic and electrical products, Daystrom Incorporated, has opened its first overseas manufacturing plant at Gloucester.

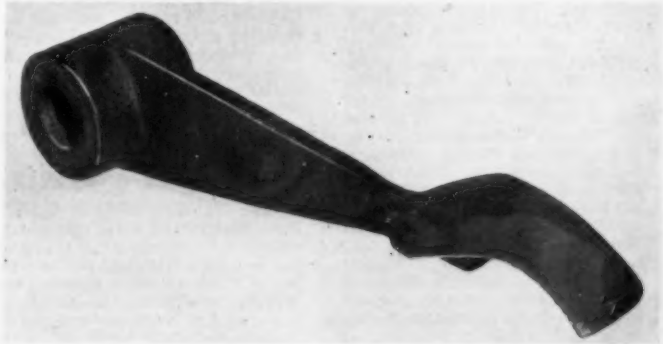
The firm, known as Daystrom Ltd., has been operating in leased premises in Gloucester for the past year. The managing director is Mr. A. E. B. Perrigo.

The new building, which houses plant and offices, covers 10,000 sq. ft., and is designed for expansion to 70,000 sq. ft. The plant will manufacture and distribute 25 different units of the company's "Heathkits"—designed for "hi-fi" radio, and do-it-yourself enthusiasts.

The British firm may later introduce some of the wide variety of electronic and electrical equipment produced by its parent company in America.

HOW MANY MILLION OPERATIONS?

A CUSTOMER of Joseph Rhodes and Sons Ltd., the press manufacturers of Wakefield, recently ordered a replacement pedal for a power press. The old part was sent for examination; the leather sole of the operator's shoe had completely worn through the metal after long years of use. Records showed that the press had been in continuous use from the end of last century and it is difficult to imagine how many millions of strokes it must have made in that time. The press is still at work—but with a new pedal. It is hoped also that the operator has a new shoe!



ALUMINIUM MERGER

THE Delta Metal Co. Ltd. has formed a new company, James Booth Aluminium Ltd. to acquire the whole of the aluminium and light alloy interests of its existing subsidiary, James Booth and Co. Ltd.

The new company will have an issued capital of £10,000,000, of which Delta will contribute £5,000,000 by way of existing assets, and Kaiser Aluminium and Chemical Corporation £5,000,000 by way of additional finance. The new finance will be used to expand and re-equip the company's works at Kitts Green, Birmingham, which will then become one of the most modern manufacturing plants of its kind in the country, capable of producing a complete range of commercial products, as well as the more specialized lines with which the company's trade name " Duralumin " has been particularly associated in the past.

The management of the new company will remain in the hands of the Delta Group, and the board of directors will comprise : Mr. W. E. Ogden (chairman of the Delta Metal Co. Ltd.) chairman ; Messrs. W. W. Dolton, W. J. Vaughton, A. F. Thomas and D. H. H. Clarke from the Delta Group, and Messrs. D. A. Rhoades, T. J. Ready and A. H. Branstad from Kaiser Aluminum. Mr. W. J. Vaughton has been appointed managing director and Mr. A. H. Branstad assistant managing director ; Sir Horace Clarke, the present chairman of James Booth and Co. Ltd., has been invited to become honorary president.

Provision has been made to ensure that control of the new company will not pass out of the United Kingdom.

The Delita contribution of £5,000,000 by way of existing assets includes the whole of the Kitts Green Works of James Booth and Co. Ltd. and the plant installed therein. It also includes the 12,000-ton forging press at the Halberton Street Works of James Booth, together with the goodwill of the aluminium business and the benefit of the important trade marks such as Duralumin, Dural, Aldural, Simgal and a number of others.

James Booth and Co. Ltd. has specialized in the strong aluminium alloys, and its connections with the aircraft industry in particular, go back to the earliest days of aircraft construction in this country.

The new finance being provided by Kaiser will be used first, in re-equipping the Kitts Green Works and bringing it into line with all modern techniques, and second, for the installation of new rolling equipment for the production of sheet, strip and plate in pure aluminium and soft aluminium alloys. This will be an entirely new development of the James Booth production.

The new plant will enable sheets and plates to be made in widths as large as any other manufacturing facilities in this country. Provision will be made for the production of corrugated sheets, embossed sheets and circles. The new products will be of great interest to those concerned with shipbuilding, road and rail transport, building, atomic energy, domestic utensils and many others, in addition to the traditional role of the James Booth organization in the aircraft field.

It will be recalled that Sir Horace W. Clarke was the pioneer in this country in the production of strong alloys, and it will be of great interest to the many customers of James Booth that the range of products will be extended to cater for every need in the wrought field instead of the products being limited to those related to strong alloys.

The special directors of James Booth and Co. Ltd., Mr. D. E. Bunce (also secretary), Mr. G. Meredith and Mr. C. Smith, are to be appointed special directors of the new concern, and the other senior executives of James Booth concerned with aluminium, will ensure continuity under the new arrangements.

Mr. W. J. Vaughton, the managing director of the new company, is very well known, particularly in the Midlands, through his position as deputy managing director of The Delta Metal Co. Ltd., and may be expected to bring to the new company the foresight and energy which has contributed in large measure to the expansion of Delta in recent years.

BRITISH AGENT FOR U.S.A. GRINDING WHEELS

ERIC H. BERNFELD LTD., London, E.8, have taken over the agency for de-burring, finishing and polishing wheels manufactured by the Weldon Roberts Rubber Co., Newark, New Jersey, U.S.A. These products are marketed under the trade name " Brightboy."

DIRECT ROLLING PROCESSES IN POWDER METALLURGY

THE Powder Metallurgy Joint Group of the Iron and Steel Institute and the Institute of Metals will hold an informal Discussion on " Direct Rolling Processes in Powder Metallurgy " in the Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1, on Tuesday, April 12, 1960.

Programme

10.30 a.m. to 12.30 p.m.

Presentation and discussion of the following three papers :—

(1) MARSHALL : " Some Mechanical Requirements of Plant for the Roll Compacting Process."

(2) DIEBEL, THORNBURG and EMLEY : " Continuous Compaction by Cyclic Pressing."

(3) J. K. BEDDOW and P. G. FORRESTER : " Continuous Sintering of Copper-Lead to Steel."

2.30 to 5 p.m.

Presentation and discussion of the following four papers :—

(4) EVANS and SMITH : " The Compaction of Metal Powders by Rolling. I—The Properties of Strip Rolled from Copper Powders."

(5) EVANS and SMITH: " The Compaction of Metal Powders by Rolling. II—An Examination of the Compaction Process."

(6) WORN and PERKS : " Production of Pure Nickel Strip by the Direct-Rolling Process."

(7) HUNT and EBORALL: "The Rolling of Copper Strip from Hydrogen-Reduced and Other Powders."

(Papers Nos. 4, 5 and 6 were published in *Powder Metallurgy*, 1958, No. 3 ; the remainder will be printed in 1959, No. 5).

5.30 p.m. approx.

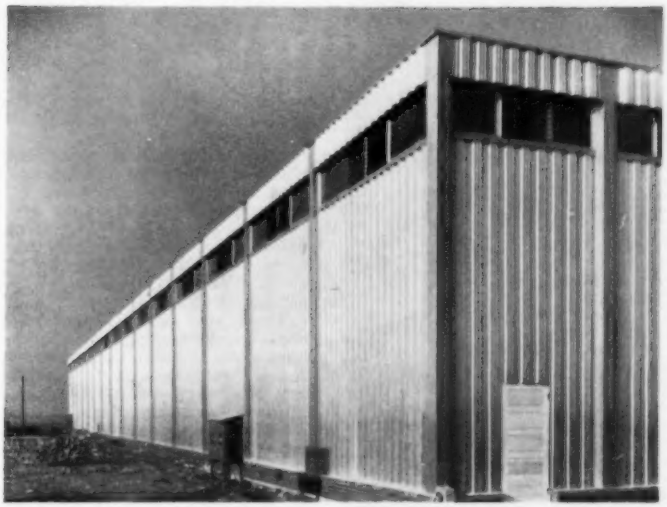
Cocktail Party in the Bishop Partridge Hall at Church House (Tickets, price 12s. 6d. each). Visitors will be welcome ; tickets of admission to the meeting are not required.

NEW ADDRESS

SOLUS-SCHALL LTD., have movd their Sales, Administration and Accounts Departments to County Building, Honeypot Lane, Stanmore, Middlesex (Tel. Wordsworth 4300).

This change represents the first step in the company's expansion programme and it is planned for the remainder of the organization to be under the same roof within the next few months.

The service department will, for the time being, continue to operate from 15/18, Clipstone Street, London, W.1. (Tel. Museum 5080).



PRODUCTION EXHIBITION

THE Fourth Production Exhibition will be held in the National Hall, Olympia, London, from April 25 to 30, 1960.

This Exhibition has a special appeal to management and, in particular, to all those in industry whose task it is to plan for productivity. It draws a large audience of students from Technical Colleges, and hundreds of firms send organized parties of staff, employees and apprentices.

The Exhibition is selective, and all exhibits are related to the topic of producing goods more cheaply and efficiently. It provides an effective cross fertilization of ideas of importance in every industry.

In 1960, it promises to contain features of more than usual value, and one prominent display will consist of the use of computers in Production Control which will create great interest.

In addition to exhibits by Development Associations, such as the British Electrical Development Association and the Tin Research Institute, the British Productivity Council, the Central Electricity Generating Board, the British Association for Commercial and Industrial Education, the British Standards Institution are exhibiting, as well as management advisory services.

An impressive exhibit will be staged by a leading car manufacturer to show how the best principles of achieving quality allied to productivity have been applied to their own production.

As a result of skilful planning and design and careful attention to safety factors, a specially low rate of insurance is applicable to one of their latest models.

A further interesting feature in the Exhibition will consist of exhibits by many small firms who in numbers form a high percentage of the total engaged in engineering in the U.K.

Once again a number of Technical Colleges will illustrate modern methods of training in Production Technology and allied topics.

The extremely high standard set in planning this Exhibition has received support from many enlightened firms in industry. Details of these exhibits will be announced shortly.

Concession tickets are available for firms to send organized parties at a special rate of 13s. per dozen tickets post free. Personal season tickets are also available.

Applications for Group Visit tickets and Season tickets should be made to: The Production Exhibition, 11, Manchester Square, London, W.1. Tel. No. HUNter 1951.

During the period of the Exhibition, the British Productivity Council will be responsible for organizing the Conference entitled "Productivity—Men and Methods." This Conference will be divided into eight Sessions.

RIGIDAL SEAMWALL

RIGIDAL SEAMWALL was introduced by the British Aluminium Co. Ltd. in June, 1959, and was recently used for the first time in a major installation at Longbenton, near Newcastle-upon-Tyne, for C. A. Parsons and Co. Ltd.

Aluminium has all the requirements for a wall cladding material. It is light, strong, durable, easily maintained, and has a good appearance both before and after weathering. It has also the great advantages of not being subject to loss by breakages, is easy to fix and has a good fire resistance and thermal insulation.

Rigidal Seamwall is a new system of wall cladding with a bold profile particularly suitable for large industrial buildings. It can be fixed with concealed fastenings to any type of sheeting rail and is available in lengths up to 40 ft. No drilling or punching of holes is necessary, and the joints are completely sealed by built-in caulking. The new building (left) is 280 ft. long with a width of 81 ft. 5 in. Steelwork stanchions are spaced at 18 ft. 6 in. centres and the Seamwall panels are fixed to sheeting rails at 6 ft. centres. The steelwork contractors were Alexander Findlay and Co. Ltd. and the sheeting contractors: Freeman, Morrison Ltd.

BRITISH AGENCY FOR GERMAN PRESSES

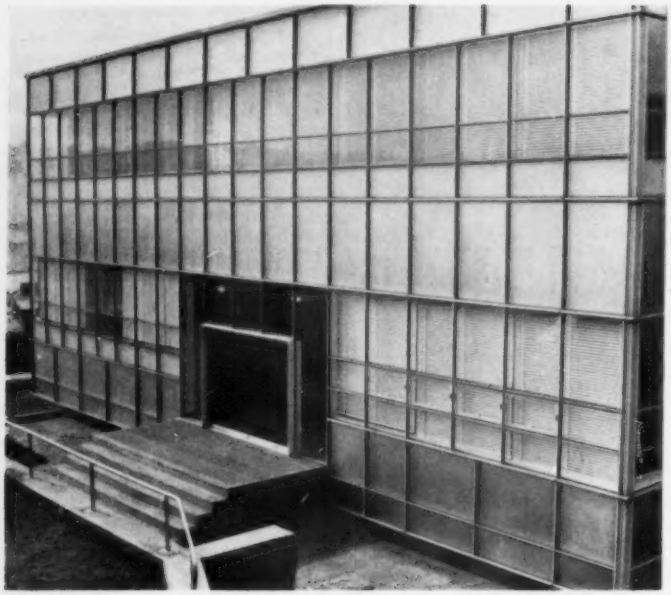
THE Press and Shear Machinery Co. Ltd., Acton, London, W.3, have been appointed exclusive distributors in the U.K. for Theodor Grabener, Germany. The range of machines concerned includes open-fronted and double-sided mechanical presses up to 1,000 tons, toggle-action, embossing and coining presses up to 600 tons and mechanical press brakes and heavy-duty shears.

VENESTA NOW A HOLDING CO.

VENESTA LTD. is now a holding company and its operating activities have been transferred to the following subsidiary companies:—

Venesta Foils Ltd. Venesta Plywood Ltd. Venesta Tea Chest Co. Ltd. Venesta Metal Containers Ltd.

Negotiations between the company and Reynolds T.I. Aluminium Ltd. are following their natural course, and it is expected that Venesta Foils Ltd. will, in due course, be bought by Reynolds T.I. Aluminium Ltd., and its name changed to British Aluminium Foil Co. Ltd.



STAINLESS-STEEL CLADDING FOR NEW CHEMICAL LABORATORY

EXTENSIVE use of stainless steel has been made in the construction of a new two-storey chemical laboratory at the Stocksbridge works, near Sheffield, of Samuel Fox and Company Ltd., a subsidiary of The United Steel Companies Ltd.

An outstanding feature of the building, which centralizes the work previously carried on in several separate laboratories, is the employment of stainless steel as an external wall cladding. The wall panels consist of 26 gauge stainless steel sheets, diamond patterned, and electro-polished to a matt finish which prevents glare and reflectivity. The sheets are bonded to half-inch Asbestolux board. The steel is Silver Fox 20, containing 18 per cent chrome and 8 per cent nickel.

The curtain walling was supplied and erected by the Crittall Manufacturing Co. Ltd. and is one of the first examples of their Fenestra 237 system, which makes use of Neoprene as a bedding material, thus eliminating much of the caulking work associated with conventional systems.

Another interesting feature of the curtain wall is that the main structural extrusions are horizontal and are positioned where a horizontal division is predetermined by the ceiling and cill heights. This gives freedom to the architect to position the vertical members where they are best suited for spandrels and glazing, and has enabled the number of wall panel sizes to be kept to a minimum.

FAN MANUFACTURERS OPEN EXHIBITION BUILDING

PERHAPS the most interesting single display in the new permanent exhibition building at the Tottenham, London, N.17, head office address of Keith Blackman Ltd., makers of the "Tornado" range of fan engineering and industrial gas equipment, is a pair of propeller fans. Both were made by Keith Blackman, both are direct driven by motors made by Keith Blackman, both are of approximately 12 in. diameter. Here the similarity ends for one was made in 1897, the other in 1959. The veteran fan is in fact one that was returned to Tottenham after 54 years continuous service in ventilating office accommodation in a town hall. It was still in working order but unsuited to a pending change in electric supply.

The new, specially built showroom is designed to show users, prospective users, trade associations and student bodies a broad cross section of the small to medium ranges of "Tornado" fans and ancillary equipment "in the flesh." These include axial and propeller fans, centrifugal fans, blowers and exhausters. The smallest fan displayed is a 1½ in. dia. blower for the cooling of valves and other electronic equipment; the largest is a 60 in. dia. variable-pitch axial fan impeller for general ventilating, mine ventilating and cooling purposes. Ancillary equipment is represented by welding fume exhaust units, a range of air filters, various sizes of sleeve and ball bearings produced in the company's Scottish foundries, grinding and polishing dust exhaust units and man-hole ventilators. Many exhibits including solid p.v.c. fume-removing centrifugal fans, selected from the company's stocks of standard equipment, are held available for quick deliveries.

Recent additions to the "Tornado" range are also in evidence, they being the new "Aristocrat" centrifugal fans, the Keith Blackman Air Circulator for lounge, restaurants, foyers, banqueting halls, etc., and a working model of the Series TF Collector of fine dry dusts which has been added to a fast expanding range of dust collecting and settling equipment.

A special display relates to equipment concerned with implementing the conditions of the Clean Air Act. This sections shows a model of a combined induced draught and grit arresting fan; types of PD-KB tubes employed in tubular dust collectors that are made in collaboration with Prat-Daniels (Stroud) Ltd., a Type AR(W) backward bladed induced draught fan impeller, and photographs of electrostatic precipitators.

Industrial gas equipment is also confined to a special section and here is to be found a wide variety of apparatus related to the efficient burning and controlling of gas. These include industrial burners, low-pressure and high-pressure injectors, automatic mixture controllers, air-blast injectors and burners and rotary compressors.

CHINA ORDERS BRITISH EQUIPMENT

CHINA has placed another order to the value of £8,000 for six gas-liquid chromatographic analysis apparatus manufactured by Griffin and George Ltd., Alperton, Middlesex. This is the second large order to be received from China in 12 months, making the number of these instruments now in use in China nine.

Forthcoming Events . . .

April 12

Institute of Welding. Open meeting of the Technical Committee on Standardisation, at 54, Princes Gate, S.W.7. Ticket only.

April 13

Institution of Plant Engineers (Dundee Branch). "Types and Uses of Eutectic Welding Alloys for Engineering Purposes," at the Taypark Hotel, West Ferry, Dundee. 7.30 p.m.

April 14

Institution of Plant Engineers (North East Branch). "Some Applications of Plastics in Industry," at Roadway House, Oxford Street, Newcastle-upon-Tyne. 7 p.m.

April 20

Institution of Plant Engineers (Kent Branch). "Ferrous and Non-ferrous Welding," at the Railway Hotel, Dartford. 7 p.m.

Institute of Welding, (North London Branch). Annual general meeting, at 54, Princes Gate, S.W.7. 7.30 p.m.

April 25

Institution of Mechanical Engineers (Industrial Admin. and Engineering Group). "A Comparison of Anglo-American Productivity Figures," discussion, at 1, Birdcage Walk, London, S.W.1.

April 26

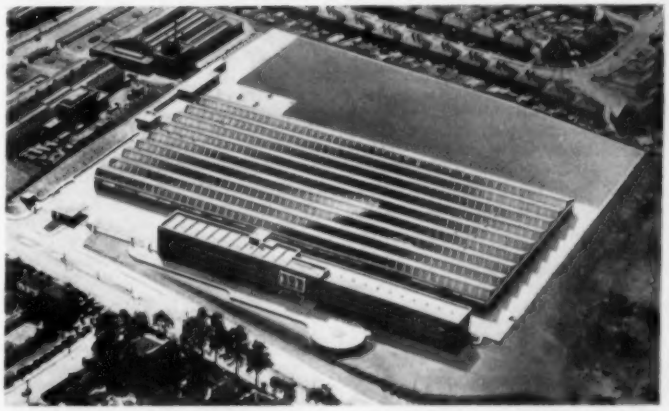
Institute of Sheet Metal Engineering (South West Branch). "Future Developments in the Steel Industry," forum in the Department of Engineering, University of Bristol. 7 p.m.

April 29

Institution of Plant Engineers (Birmingham Branch). "Materials Handling—Fork Trucks, etc., Maintenance and Repair," at the Imperial Hotel, Temple Street, Birmingham. 7.30 p.m.

ELECTRONIC CONTROLS

THE Donovan Electrical Co. Ltd., of Stechford, Birmingham, 33, announce the establishment of an Industrial Electronics Division. The company has been licensed by The Austin Motor Co. Ltd., and Hivac Ltd., to supply and manufacture equipment employing the recently announced "Access" system of electronic control (Austin Cold Cathode Electronic Switching System), with particular reference to complex machine tool and conveyor applications.



THE photograph above shows the new factory of Moore and Wright (Sheffield) Ltd. Situated in a smokeless zone on the outskirts of Sheffield the new factory has a site area of nearly twelve acres. The company was founded in 1906 and in 1945 was acquired by John Shaw and Sons, Wolverhampton, who celebrated their 150th anniversary that year. Moore and Wright are internationally known for the manufacture of precision and hand tools, in particular micrometers.

Industrial Films

A FILM entitled "Infra-red heat in industry" is available from The General Electric Co. Ltd. The film explains what infra-red heat is and shows in interesting fashion its applications to industrial processes such as plastics, paint stoving and nylon setting. The film is a 16-mm. colour sound film for projection at silent speed and has a running time of 18 minutes. Applications for the free loan of the film should be made by interested bodies to: Industrial Heating Department, G.E.C., Magnet House, Kingsway, W.C.2.

* * *

TWO films have recently been produced for Wolf Electric Tools Ltd., Hanger Lane, London, W.5.

"One Jump Ahead" is a contribution to the wider understanding throughout the engineering trades, of the immense—but often unsuspected—potentialities of modern "universal" electric tools for heavy production and special work.

The story illustrates the points of adaptability, performance, reliability and precision, being made convincingly yet with a complete absence of sales propaganda. The word "Wolf" is not once mentioned.

The leading role is played by Mr. Raymond Baxter, so well-known in connexion with B.B.C. industrial and scientific television programmes. The film was made in collaboration with four well-known engineering firms, in whose factories all the action sequences were shot under normal working conditions. This gives to the story a tremendous sense of reality and authenticity.

Filmed in colour on the latest 16-mm. Kodak Ektakrome stock, this will be shown by the company at engineering centres throughout the country. In due course copies will be available through Industrial Film Libraries, and, also to English-speaking countries throughout the world.

The co-operation of the following firms appearing in the film is gratefully acknowledged: Modern Engineering (Bristol) Ltd., Bristol; Millars Machinery Co. Ltd., Bishops Stortford; Willenhall Radiator Co. Ltd., Wolverhampton; John Lang and Sons Ltd., Johnstone, Scotland.

The film was produced by United Motion Pictures Ltd.

The second Wolf film, which is in colour and runs for 22 minutes is entitled "People Like Us." It has two main features, the first being to sell the benefits of Wolf Home Power Tools and second to educate the public in their proper use. The film features a young couple with two children who with the aid of a "Wolf" Kit make many items of furniture for their home.

Books for Your Library

Vacuum Metallurgy. Edited by R. F. Bunshah. New York and London : 1958. The Reinhold Publishing Corp. and Chapman and Hall Ltd. 472 pages. 100s. net.

THIS book, which is one of the Materials Technology Series, is made up of lectures presented during a course on Vacuum Metallurgy given at New York University in June 1957, and also June 1958. The papers presented at the course and published now in book form cover every aspect of vacuum metallurgy including equipment, measurement and techniques. In almost very instance the authors of the papers are experts in their own field and it is particularly interesting to know that this is on an international basis and not on a national one. The book is divided up into 10 parts which are as follows :—

1. Equipment.
2. Thermodynamics and Kinetics.
3. Arcs and Arc-Melting Processes.
4. Induction-Melting Processes.
5. Electron-Bombardment Melting Techniques.
6. Degassing in the Liquid and Solid States.
7. Distillation of Metals.
8. Metallurgical Application of Vacuum Processing.
9. Analytical Techniques.
10. Future Trends.

It is very difficult in a book which is packed so full of meat to select items for particular attention. Probably the most interesting paper is that on Electron-Bombardment Melting Techniques, by H. R. Smith, Jr. of the Temescal Metallurgical Corporation, Richmond, California. The author gives a very clear description of the electron bombardment technique and devotes considerable space to the subject of evaporation of metals more volatile than the basic metal. This is an advantage in the removal of impurities but in the production of alloys it causes complications. The melting of niobium by the electron beam technique has reached a semi-commercial scale, *i.e.*, tons of ingots are being produced each month. Niobium is particularly suitable to this method of melting as it ensures the removal of oxygen, nitrogen and carbon as well as many undesirable metallic impurities.

Under the section on arc melting it is surprising not to find a paper by the personnel of the U.S. Bureau of Mines at Albany, Oregon, where so much of the development work on consumable arc melting was done. A paper by S. J. Noesen and R. M. Parke describes the Consumable Electrode Arc Melting of Refractory Metals. It is impossible to deal with the subject thoroughly in the space allowed but the authors do their best. The purification of metals is described and some indication of the problems encountered are mentioned. In particular the results of work on purification of molybdenum by consumable arc melting are given. The oxygen content of the feed powder was reduced from 250 p.p.m. to 2 p.p.m. in the ingot, while the nitrogen content was reduced from 20 to 2 p.p.m. It is claimed that no appreciable quantities of carbon and oxygen were removed during the sintering of the electrode.

H. Gruber of the W.C. Heraeus, G.m.b.H. Company of Hanau, Frankfurt, gives an excellent survey of European arc melting. This is really a description of arc-melting techniques, chiefly those designed and constructed by W.C. Heraeus who are experts in the design of this type of equipment.

One of the most interesting sections is that which describes the future trends. This is given by J. H. Moore of the NRC Equipment Corporation of Massachusetts and includes a very interesting historical background starting with the work of von Bolton and Simpson on arc melting tantalum as early as 1900. The author points out that it was the development of vacuum equipment that made possible large scale application of vacuum metallurgy. The first large industrial scale process to be operated was for the production of magnesium. Reference is made to the enormous expansion in the use of vacuum melting with molten degassing of metals on a large scale. Several companies are now operating vacuum arc furnaces up to 5,000 lb. capacity. In Germany 150-ton heats are being vacuum degassed during teeming. The importance of steel degassing is now generally accepted.

One of the sections which will be appreciated by many people is that dealing with the determination of gases in metals by vacuum fusion. This is very detailed and will prove worthy of study.

One hesitates to be critical of such a useful volume but one must deplore the use of words like "sucked out" when describing the removal of gases from metals by vacuum treatment.

G. L. MILLER.

Handbook on Electroplating, Birmingham, 1960. W. Canning and Co. Ltd., Great Hampton Street, Birmingham, 18. 631 pp. 30s. net.

THIS, the nineteenth edition of the well-known "Canning Handbook" has been considerably revised and enlarged. The sectional order has been brought into line with modern practice and the book is now divided into three main sections : polishing ; electroplating ; bronzing and lacquering. Cleaning and pickling, which form an integral part of any electroplating process, are now included in the electroplating section, and under polishing are grouped the various mechanical finishing processes, including abrasive finishing, polishing, and wire brushing. Chapters are also included on electrolytic and chemical brightening of metals and on effluent treatment. In addition, control standards are given for the various plating processes described.

In the electroplating section the first three chapters cover the necessary equipment, while the fourth deals with the general principles of the process. Although not intended to be an exhaustive study of the theories underlying electroplating processes, it will give those concerned with their practical application sufficient background knowledge for their day-to-day needs. Completing this section are chapters on pretreatment processes and detailed information on a wide range of plated deposits.

Previous editions of this book have been a part of the library of all connected with electroplating for many years, and this new edition, even more valuable in its recent form, will perpetuate this tradition.

INTERNATIONAL CORROSION CONGRESS

THE 1st International Congress on Metallic Corrosion which is intended to cover the broad field of corrosion under several headings will be held in the Imperial College of Science and Technology in London from April 10 to 15, 1961.

The scientific programme is being organized by a special committee under the chairmanship of Mr. L. Kenworthy, chairman of the Corrosion Group of the Society of Chemical Industry.

Publications for Industry

Frank Nixon, president of the European Organization for Quality Control has contributed a useful article in the "FBI Review," journal of the Federation of British Industries, on the control of product quality. Aiming to convince management executives of the significance product quality control plays in British industry and its subsequent success in foreign markets, Mr. Nixon poses three basic questions; the variations likely to occur during manufacture; the extent of variation acceptable to the customer; and the steps necessary to bring these into line. Many of the examples given are from American industry and show reductions in scrap and rework costs of up to 50 per cent. The interest being shown in this field may be seen from the increasing number of courses being held throughout the country. The "FBI Review" may be obtained from the Federation of British Industries, 21, Tothill Street, S.W.1.

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A recent issue of "Dawe Digest," the quarterly technical bulletin of Dawe Instruments Ltd., 99-101, Uxbridge Road, London, W.5, carries two topical articles on sound-level measurement and nuclear-heat-exchanger cleaning. The increased realization of the effect of noise levels on health and working efficiency, and the legal limits imposed in many countries, particularly at airports, has led to the design of the new "Objective Noise Meter Type 1405." Based on a Ministry of Supply requirement, the instrument is said to feature improved performance under adverse conditions of vibration and temperature, greater dynamic range (34-130dB) and stability and an accuracy unaffected by current noise and microphony. Calibration facilities are provided for setting and checking prior to use on location.

With the advent of nuclear-power-plant designers requiring higher gas temperatures, severe corrosion problems have been envisaged in the heat exchangers. The effect of foreign matter in the reactor core picked up by the hot radioactive gas could have undesirable effects. The need for cleaning the exchanger to a high standard, much of the surface being inaccessible by mechanical means, pointed to the ultrasonic-energy method, incorporated in the Dawe Type 1153A Soniclean Generator. The generator has a 4-kW. peak output and drives seven B36 stainless-steel-cased transducers, the displaced matter being held in suspension to avoid redeposit on the element. The Windscale prototype reactor, at the moment in project, anticipates having the exchangers cleaned with this new plant.

* * *

The majority of fusing furnaces installed in this country, of all types, are either town-gas or oil fired, but it is the opinion of H. Bryan, the author of "Electric Furnaces for Fusing," a paper presented to the Midland section of The Institute of Vitreous Enamellers, that insufficient knowledge of the construction and running of the modern electric furnaces has caused many advantages to be overlooked. In his paper, he sets out to explain the benefits obtained from electric furnace fusing over the more conventional methods, and Metalectric Furnaces Ltd. have produced the paper in booklet form which is obtainable from the company at Cornwall Rd., Smethwick 40, Staffs. It makes interesting and instructive reading and underlines the careful consideration necessary when the installation of new furnace plant is being discussed.

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The January issue of the "Platinum Metals Review," a quarterly journal surveying the research and developments of platinum metals in industry, published by Johnson, Matthey Co. Ltd., Hatton Garden, E.C.1, contains an article on the use of palladium in printed circuits.

The use of printed circuits in a variety of domestic and electronic equipment and more recent developments in this field, have shown the importance of the contact properties of the track. Electronic computor manufacturers seeking to make available a series of sub-circuits are now able to design circuit boards one edge of which may be plugged into a suitable socket enabling a particular mathematical operation to be used at any stage in the "programme." The physical properties of palladium make it particularly suitable for plug applications, and the relatively low cost of the material gives it an added economic interest.

Also included in this edition is a brief mention of the Anotrol process, developed by the Continental Oil Co. Ltd., Baltimore, U.S.A. The process is based on the formation of a thin film, deposited by electrolysis, of high corrosive resistance to acids and alkalis. The initial deposit having been made, only a very small current is required to maintain the film. The ability to passivate plant of complex contours makes the process suitable for chemical plant since the electrode system may be situated a considerable distance from the area to be passivated.

* * *

The chairman of the Lancashire Dynamo group of companies, Lt.-Col. G. S. Marston, pays tribute to our "pioneering forbears" as an introduction to the group's recently issued technical review "Electricity in Industry, No. 17." The standardization of industrial electronic control equipment, a long felt necessity, forms the basis of an interesting article. Having recognized the importance of this several years ago, it was decided to make a detailed study, within the group, to determine the products where demand would make it a possibility. The Standard Products Division and Committee, subsequently set up to investigate customers needs and to ensure manufacture at the lowest possible cost, has since produced a range of equipment in the field of photoelectric switching. The apparent high performance of this equipment, which operates on the interrupted light beam principle, makes it suitable for a number of industrial applications. Also included in the standardization programme are electronic counting and timing instruments. Further information about equipment and articles already published by the Lancashire Dynamo Group on this subject, are obtainable from the Lancashire Dynamo Electronic Products Ltd., Rugely, Staffs.

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The second edition of "Freight Services to and from Northern Ireland," published recently by the Northern Ireland Development Council deals with the transformation in the freight and passenger services across the North Channel and the Irish Sea. The increase in industrial activity in Northern Ireland has necessitated extending communications, the lifeline vital to her growing prosperity. The brochure describes the general cargo, freight and passenger services available to Glasgow and Liverpool, the specially-built container ships in operation and the improved facilities at the Ulster ports. The information is clearly tabulated with a separate table for air freight services. A road and rail map in colour provides further information for shipping departments. Copies are obtainable free of charge from the Northern Ireland Development Council, 13, Lower Regent Street, SW.1.

APPOINTMENTS and STAFF CHANGES

The following appointments are announced by **Reynolds T.I. Aluminium Ltd.** and **The British Aluminium Co. Ltd.**

Mr. Gerald Lacey, commercial director, The British Aluminium Co. Ltd. as executive director (forward planning) with special responsibility for studying and co-ordinating long-term planning for the development of production, fabrication and research interests in the U.K. and overseas.

Mr. G. A. Anderson, director and general sales manager, The British Aluminium Co. Ltd. as director of products and development with responsibility for the products, development and technical service organisations.

Mr. Basil James, chief executive (Sales), Reynolds T.I. Aluminium Ltd. as director of sales.

Mr. J. Salter, director and general production manager, The British Aluminium Co. Ltd. as director of engineering.

Mr. Paul R. McGehee, chief executive (production) Reynolds T.I Aluminium Ltd. as director of production (manufactured products) with responsibility for operations at the company's mills and associated establishments.

Mr. W. B. C. Perrycoste, director and general production manager, The British Aluminium Co. Ltd. as director of production (primary products) with responsibility for mining, alumina production and aluminium smelting operations at U.K. and overseas establishments.

* * *

The appointment of Captain R. A. Villiers, C.B.E., A.M.I.E.E., R.N. (Retd.) as the first Director of the **Scientific Instrument Manufacturers' Association of Great Britain,** SIMA House, Queen Anne Street, London, W.1, was the major step in the administrative reorganization of SIMA and the beginning of a new era of expanding activities. To facilitate this aim, Mr. G. L. Knight has been appointed assistant to the director. He will operate under Captain Villiers and will be responsible for the collection and distribution of information for SIMA.

Mr. C. B. Cornelius has been appointed works manager of **A. J. Flatley Ltd.,** and will be responsible for all matters concerning production of dryers, washing machines, convector heaters, central heating equipment and other domestic appliances which are shortly to be in production.

* * *

Pearson Panke Ltd. announce that Mr. Leslie Power has recently joined their staff as representative for the Midland area.

The appointment is in line with their general policy to employ qualified engineers as representatives. Mr. Power has considerable experience of power presses and machine tools and will deal with the full range of Schuler and Schuler SMG mechanical and hydraulic presses, and sheet metal working machinery, Ungerer roller levellers, Erichsen sheet metal testing machines, E.S. photo-electric guards, etc.

* * *

Mr. H. F. Barnett, sales manager, and Mr. W. C. Steer, secretary, of **Borax and Chemicals Ltd.,** have relinquished their duties with the company. Mr. Barnett and Mr. Steer have held their positions with the company since its inception 21 years ago and have been concerned with the sale and distribution of "Three Elephant" brand products for well over 30 years.

Mr. P. J. Gilbert, who was representative in the Midlands, succeeds Mr. Barnett, and Mr. B. W. Green, who joined the company's head office staff in 1951 succeeds Mr. Steer.

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Brigadier H. P. Crosland, C.B., C.B.E., M.C., T.D., D.L., chairman and managing director of Metal Traders Ltd. has been elected chairman of the **Zinc Development Association** for 1960. The former chairman, Mr. R. T. de Poix, O.B.E., will continue as a member of the Council of the Association.

* * *

After an association of nearly 50 years with **John Summers and Sons Ltd.,** of Shotton, Chester, Mr. M. J. B. Whitby has retired from his position as London manager.

Mr. Whitby, who has many connections in the City of London, is a Member of the Court of Common Council of the City, and a Past Master of the Worshipful Company of Innholders.

Mr. Francis H. Smith, A.M.I.E.E. formerly market research and development manager, succeeds Mr. Whitby as London manager.

* * *

Vauxhall Motors Ltd. announce that Mr. K. M. Eaton has been appointed general supply manager. He succeeds Mr. G. F. Tipler, who has requested early retirement under the terms of Vauxhall's retirement plan after 39 years with the company.

Kenneth M. Eaton joined Vauxhall in May, 1929, as an engineering clerk. He was transferred to the Supply Department three years later, and was appointed equipment purchase manager in 1938. Since September, 1957, he has served on the staff of the managing director.

George F. Tipler joined Vauxhall as an apprentice in 1913. He left the company in 1919, and spent two years in India with the Handley Page aircraft company. Rejoining Vauxhall Motors in 1921 in the tool room, he became a draughtsman in the planning department a few months later. In 1927 he was appointed superintendent, and in 1928 manager, of the planning department. After a short period as cost analysis manager, he was made standards manager in 1929. He was appointed general supply manager on January 1, 1942.

* * *

Mr. Joseph Samuels, who, as a member of the board of **Winston Electronics Ltd.,** Shepperton, Middlesex, has been purchasing director for several years, has now been appointed works director in charge of production. Mr. Samuels is 49 years old and was educated at St. Mary's College and Imperial College of Science. Before joining Winston Electronics in 1954, he was for several years with Standard Telephones and Cables and later Sunvic Controls of Associated Electrical Industries Ltd. He joined the board of Winston Electronics in 1956.

* * *

Mr. J. Mackenzie-Mair has been appointed to the board of **Steel, Peech and Tozer,** a branch of The United Steel Companies Ltd., and assumes the title of director and commercial manager. Mr. W. T. Vizer Harmer remains a full-time director of the company.

The following staff changes are also announced:

Mr. M. Thomas has been appointed assistant works manager

(*Continued in page* 311)

Appointments and Staff Changes

(*Continued from page* 310)

(services) and Mr. E. Houghton assistant works manager (special duties). Mr. Houghton will be primarily concerned with manning problems arising from the conversion from open hearth to electric arc furnaces in the Templeborough melting shop.

Mr. D. R. B. Burdass has been appointed personal assistant to the general works manager. Mr. D. Reilly has joined the company as cold-rolling-mill manager. He was until recently with Guest, Keen and Nettlefolds Ltd., and will be responsible in his new capacity to the works manager, Ickles, for both the existing and new cold-rolling departments.

Mr. G. D. Jordan, who has been senior engineer in United Steel's department of operational research and cybernetics is now Templeborough melting shop project secretary responsible to the chief engineer. Mr. J. Hewitt, of the research and development department of United Steel, is senior research metallurgist responsible to Dr. B. B. Hundy, chief research metallurgist. Mr. J. Ravenscroft, who was employed by the British Iron and Steel Research Association, has joined the company as arc furnace research assistant, responsible to Mr. R. S. Howes, manager of the Rotherham melting shop.

* * *

Mr. Richard Miles, chairman and managing director of **Head Wrightson and Company Ltd.,** retired at the end of the company's financial year. He had been chairman of the company for ten years, and managing director for 25 years. He will remain on the board of the parent company.

SIR JOHN WRIGHTSON, Bt.

(Left)
H. F. PADBURY

(Right)
R. H. PARKER

Sir John Wrightson, Bt., vice-chairman and managing director for the last ten years, has been appointed to succeed him as chairman and managing director.

Mr. Peter Wrightson, O.B.E., managing director since 1955 has been appointed vice-chairman and managing director.

* * *

It is announced that the **Pressed Steel Co. Ltd.** has taken over the aviation interests and operation of the Oxford Airport at Kidlington. The management will comprise: Mr. J. W. Gillespie, general manager, and Mr. L. V. Harcourt, aerodrome manager, both of whom are employed by the Pressed Steel Company.

The company emphasizes that this is in no way intended to impose any restrictions on other users of the airport, and that it is intended to continue with all aspects of flying at present in operation, including the maintenance and servicing of aircraft in accordance with the regulations as laid down by the Ministry of Transport and Civil Aviation and Air Registration Board.

* * *

Mr. C. E. Hollinghurst, M.Eng., A.M.I.C.E., has been appointed a deputy chief engineer (civil) on the Highways Engineering Staff of the **Ministry of Transport** at headquarters.

Mr. J. A. S. Dakers, B.Sc., A.M.I.C.E., has been appointed to succeed Mr. Hollinghurst as divisional road engineer, Metropolitan Division.

Mr. H. S. Keep, M.C., B.Sc. (Eng.), A.C.G.I., M.I.C.E., has left South Eastern Division to take up a new post as an assistant chief engineer at headquarters. He is succeeded as divisional road engineer, South-Eastern Division, by Mr. T. E. Hutton, B.Sc.(Hons.), M.I.C.E., A.M.I.Mun.E.

Mr. L. P. F. Hubbard, B.Sc., A.M.I.C.E., A.M.I.Mun.E., has been appointed divisional road engineer, South Western Division in succession to Mr. Hutton.

* * *

The following senior appointments to the production and administration staff of the Spencer Works, now under construction at Llanwern, near Newport, Mon, are announced by **Richard Thomas and Baldwins Ltd.:**

Mr. R. H. Parker, works manager; Mr. H. F. Padbury, assistant works manager (Coke, Iron and Steel); Mr. R. Raby, coke ovens manager; Mr. O. W. Reynolds, education and training officer; Mr. S. I. Webber, assistant chief accountant.

* * *

Mr. James Baxter has been appointed Field Sales Manager for the Scottish Branch of **Griffin and George Ltd.,** Ealing Road, Alperton, Middlesex.

Mr. Baxter, who is 33, was born and educated in Dundee. He studied at Stobswell Secondary School, and Dundee Technical College, specialising in mathematics, physics, chemistry and botany. His first job, also in Dundee, was as an assistant chemist in the analytical and process control departments of James Keiller and Sons Ltd.

Mr. R. E. F. Sykes, A.M.I.W.M., has been appointed general manager of **Griffin and George (Laboratory Construction) Ltd.,** with works at Perry Barr, Birmingham, and Mitcham, Surrey, a subsidiary of the Griffin and George Group.

Mr. Sykes succeeds Mr. A. E. Lambert, who has recently retired.

* * *

Causeway Reinforcement Ltd. of Five Ash Works, Dover Road East, Northfleet, Kent, have appointed Mr. T. C. Leach as their representative in the five Midland counties for their surface armouring and multi-purpose trestles. The company have also appointed Mr. C. T. Withy as their representative in Lancashire and Yorkshire. Causeway Reinforcement Ltd. is a member of the Amber Group of Companies.

(*Continued in page* 312)

Appointments and Staff Changes

(*Continued from page* 311)

Frank C. Young has joined the Public Relations Division of **Simms Motor and Electronics Corporation Ltd.**

Mr. Young, after serving his engineering apprenticeship with the Taw Engineering Company of Hornsey, graduated into journalism with the Amalgamated Press Ltd. He has a wide knowledge of the motor industry gained through his long association before the war with the Modern Transport Publishing Company, of which he was technical editor. More recently he has held appointments as associate editor of *Motor Commerce* (now our sister journal *Motor Industry*), as North American correspondent of *The Engineer* and press officer of Associated Commercial Vehicles Ltd.

* * *

The Minister of Power has reappointed the following members of the **Iron and Steel Board** as from June 1, 1960:

Sir Lincoln Evans, C.B.E., deputy chairman; Mr. A. G. Stewart, Mr. A. E. Pearce, Sir Charles Connell, Sir Henry Spurrier and Sir Kenneth Hague.

The appointment of Sir Lincoln Evans, who has been full-time deputy chairman of the Board since it was formed, will be on a part-time basis from June 1, 1960.

* * *

Mr. G. P. Thompson, until recently manager of transformer factory at Rugby Works, has been appointed manager—Manufacturing, **A. E. I. (Rugby) Ltd.**

Mr. Thompson joined BTH Rugby as a student apprentice in 1930, and was later appointed to the staff of the transformer engineering department. In 1943, he became technical assistant to the superintendent of the transformer factory.

In 1949, Mr. Thompson went to study transformer methods in France, and later at the Pittsfield Factory of the G.E. Company, America. He was appointed chief assistant to the superintendent of the transformer factory in 1950, and manager of that factory in October, 1953. As manager of manufacturing at Rugby Works, he succeeds Mr. D. Edmundson, whose appointment as general manager was recently announced.

To succeed Mr. G. P. Thompson, A.E.I. announce the appointment of Mr. R. Thomson, A.M.I.W.M., as manager of the transformer factory.

Mr. Thomson joined the British Thomson-Houston Company—now A.E.I. (Rugby) Ltd.—in 1939 as a jig and tool draughtsman. In 1940 he transferred to the company's Peterborough factory as development engineer (aircraft and radar components), assistant production engineer, and production engineer responsible for the changeover from aircraft production to domestic appliances.

In 1945, he returned to BTH Rugby Works as assistant to the general superintendent. A year later he was appointed chief planner, motor, generator and rectifier departments, and in 1955, transferred to transformer engineering department. He was appointed assistant superintendent, transformer factory in May, 1956, and superintendent in October, 1957.

* * *

Mr. G. A. Hutcheson, M.Sc., A.M.I.Mech.E., has been elected an executive director of NUMAS, the advisory service set up by the **National Union of Manufacturers** to promote the application of modern management techniques in manufacturing industry.

Before joining NUMAS, Mr. Hutcheson held a senior appointment with Imperial Chemical Industries advising on the application of work study and related analytical methods to the planning and development of major capital programmes.

* * *

The appointment of a sales manager and two new representatives for Sifbronze welding products is announced by **Suffolk Iron Foundry (1920) Ltd.,** Stowmarket.

The sales manager is Mr. W. E. A. Williams, formerly the company's London and South East area representative, who joined Suffolk Iron Foundry from F. J. Edwards Ltd. in 1958. Mr. Williams will operate from the Stowmarket Head Office.

The new representatives are Mr. G. A. Edmunds, who has taken over Mr. Williams' representation in London and the South East, and Mr. S. E. Witherington, who has been appointed as Birmingham Area representative in the place of Mr. E. Christie, who has returned to headquarters at Stowmarket owing to ill-health.

Mr. G. A. Edmunds will work from 89, Ashbourne Road, Mitcham, Surrey (Tel.: MITcham 8046), and Mr. Witherington from 21, Stud Lane, Birmingham 33 (Tel.: Stechford 5804).

* * *

The British Iron and Steel Research Association announces that Mr. S. S. Carlisle, M.Sc., A.M.I.E.E., head of the physics department, has been appointed an assistant director. He will be especially concerned with the co-ordination of the Association's work on automation and information handling which is now a vital part of the research programme. His work will include co-operation with laboratories and firms outside the Association with a view to increasing the overall research and development effort devoted to automation in the steel industry.

Mr. Carlisle joined BISRA in 1946, and in 1947 was appointed head of the instruments section of the physics department. In 1954 he was made head of the South Wales Laboratories where the Association's work on steel-coatings research is carried on; in 1958 he returned to London as head of the physics department.

* * *

Mr. G. R. Dutton has been appointed to the main board of the **Firth Company Ltd.,** Warrington, a member of the Firth Cleveland Group. Mr. Dutton was formerly an executive director. He was, and will continue to be, in charge of the sales of the company's products.

* * *

Borax Consolidated Ltd. announce the appointment of Mr. G. N. Blow as their Midlands Area manager in succession to the late Mr. D. G. B. Sleath.

Mr. Blow has been with the company since 1953 as a local representative in the Birmingham Area.

* * *

Mr. F. W. Tomlinson, managing director of **Pyrotenax Ltd.,** Mr. J. M. Willey, director and general manager of **Murex Welding Processes Ltd.,** and Mr. P. S. Bryant of **Murex Ltd.,** have been appointed to the board of Murex Ltd., Rainham. Mr. Tomlinson has also been appointed to the board of Murex Welding Processes Ltd., Waltham Cross.

* * *

It is announced that Mr. J. R. Edwards, works superintendent and a special director of **Shepcote Lane Rolling Mills Ltd.,** has been appointed a director of that company.

It is also announced that Mr. F. Brown, chief engineer, has been appointed a special director.

* * *

Guest Keen and Nettlefolds (South Wales) Ltd. announce the following appointments: Mr. R. Stewartson, assistant works manager; Mr. N. A. Makin, development engineer; Mr. R. D. Hooper, nail factory manager; Mr. H. H. Matthews, nail sales manager; Mr. Tom Jones, assistant nail sales manager; Mr. D. T. Davies, section mills manager; Mr. E. G. Davies, deputy chief accountant; Mr. G. B. Smith, wire rod mill manager; Mr. Len Davies, assistant export manager.

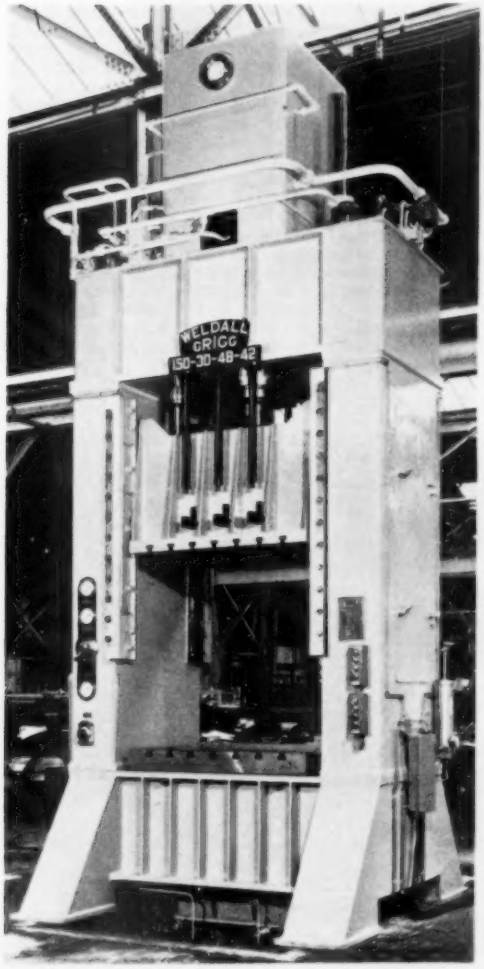
New Plant and Equipment

Hydraulic Presses

A WELDALL-GRIGG deep-drawing press (Fig. 1) demonstrated recently was of 150 tons capacity with a bolster and slide area of 48 in. left to right and 42 in. front to back. Die-cushion equipment consisted of twin 25-ton hydro-pneumatic cushions, fitted with two-stage blank-holding pressure control. The press has a fast approach speed of 10 in. per sec., with a variable pressing speed between zero and 1.3 in. per sec.

The design conforms to the "Weldall-Grigg" standard range of presses, which are of welded steel construction. (Standard range 50 to 1,000 tons). The bed and crown are manufactured from extra-deep steel plate and substantially ribbed to give rigidity. The side frames are fabricated to form a steel box section and keyed to the bed and crown, the whole assembly being secured by large shrunk-in tie rods.

Fig. 1.—Hydraulic press



The press tonnage is variable over a wide range and is altered by rotating the main-ram tonnage control which is conveniently positioned on the front of the l.h. side frame, together with the main ram and die-cushion pressure gauges. The die-cushion tonnage can be varied between zero and maximum. The cushion can be locked at the bottom of its stroke and reinitiated at a predetermined position during the return stroke of the press slide.

Operation of the press is controlled from a push-button station mounted on the front of the r.h. side frame, and the slide can be "inched" down, run on single cycle automatic, or continuous cycle. The stroke controls for both the slides and the die cushions, are housed in the r.h. side frame. Adjustment by means of a hand wheel attached to the appropriate leadscrew, gives easy positioning to the following: Slow-down adjustment, top stroke reversal adjustment, bottom stroke reversal adjustment, delayed die-cushion adjustment. A comparable range of mechanical presses is also available.

"Weldall-Grigg" presses are designed and sold by Charles S. W. Grigg Ltd., Hounslow, Middlesex, and manufactured by Weldall and Assembly Ltd., Stourbridge, Worcs. Both the foregoing companies are members of Triplex Holdings Ltd.

Strip-forming Compound

THE Orcene Co. Ltd., Victoria Street, Warwick, have produced a fortified soluble-oil type of compound, ORPI-L-940, for forming coated steel strip and which has been found satisfactory in some cases for use in drawing plastics.

Special advantages claimed for this compound are that it will form or draw the coated metal without injury or rupture to the organic film superimposed upon it and is easy to degrease.

Contact Welding Electrode

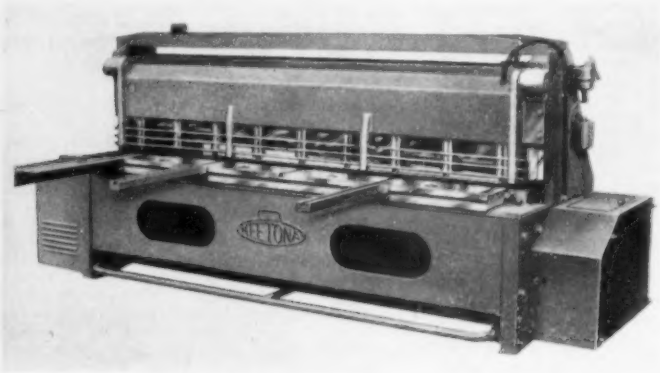
PHILIPS Electrical Ltd., are now marketing a new zircon iron powder coated electrode which has been specially developed for contact welding of all mild and low-alloy steels in downhand, standing fillet and horizontal-vertical positions.

The mechanical properties, X-ray qualities, and the high impact values, which are in excess of conventional low-hydrogen electrodes, make the C.16 particularly suitable for the demanding conditions of nuclear engineering.

The C.16 has been approved by the Ministry of Transport and Lloyds Register of Shipping.

The welds produced, which are flat or slightly convex, have a neat and clean appearance. The ductility of the C.16 is claimed to be higher than that of other electrodes. Slag is self-removing.

A leaflet giving full technical and test data and chemical analysis is obtainable from Philips Electrical (Industrial Products Division), Century House, Shaftesbury Avenue, London, W.C.2.



Guillotine Shears

A NEW range of ¼ in. capacity shears is now available from Keeton, Sons and Co. Ltd., of Sheffield, a member of the Firth Cleveland Group. The first model, the Keetona 8 ft. by ¼ in. shears (Fig. 2) illustrates the features of the new models.

For the first time Keetona shears are supplied in fabricated steel construction, and other new features include instantaneous clutch engagement, toggle action mechanical hold down (or, alternatively, hydraulically operated hold down), easily accessible blades for changing and efficient one-point lubrication. Modern box-type construction minimizes deflection, ensures rigidity, smooth operation and a high degree of accurate shearing to the maximum capacity of the machine.

The action of the cutting beam is inclined at 2 deg. to the vertical. Using square four-edge blades, it presents the corner of the upper blade to the material, giving the same effect as with two-edge bevelled blades. The lower blade is fastened square to the table and is flush with the top. The cutting blades can be straight sided. There is no risk of the sheared material trapping between the lower blade and the back gauge, as the latter moves away from the lower blade while cutting.

The hand-operated micrometer back gauge is fitted to the shear as standard equipment at no extra cost.

Fig. 2 (*above*).—*Guillotine shears*

Multiple Punching Machine

A NEW addition to their range of punching machines has been announced by F. J. Edwards Ltd., 359-361, Euston Road, London, N.W.1. The "Besco" production geared multiple punching machine, Model 108/50, has a welded steel plate construction, with a bed 15 in. wide by 108 in. long, strongly webbed, dowelled and bolted to the main frame. With a capacity of 50 tons, it has a 1-in. stroke and is capable of achieving 62 strokes per min. (Fig. 3). The main drive is from a 5-h.p. motor mounted on a platform at the rear of the machine, through vee ropes to a ball-bearing mounted flywheel. A "Taylor" multi-drive friction plate clutch is incorporated, operated by foot treadle. An automatic brake is fitted, and the machine is designed for continuous or single operation, stopping at the top of the stroke.

Of particular interest is the provision of an electrically operated "knock-off," making the machine ideally suited for multiple production, and readily adaptable for sequence coupling with other machines on a continuous production line. Another feature is the design of the main frames which have rectangular holes 10½ in. by 9½ in. slightly above the bed level, which can be used for feeding and punching long strip material.

The ram is 4 in. wide by 96 in. long. It is well guided in adjustable slips and tee slotted for receiving multiple or single punches. The actual adjustment to ram is 2 in., controlled by a handle at the side of the machine through worm gears. The distance from the bed to ram face, stroke down, is 11 in. Twelve tee slots are provided across the bed face for die fixing, at 8-in. centres.

(*Continued in page* 316)

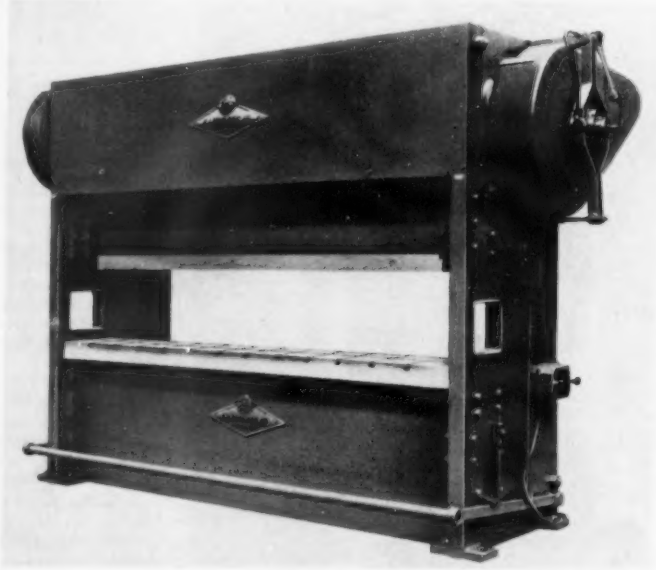


Fig. 3 (*right*).—*Multiple punching machine*

NATIONAL PENSIONS

The National Insurance Act 1959 gives employers the opportunity under certain conditions of contracting out of the graduated part of the State pension scheme. The whole subject of pensions for employees is both complicated and urgent. Every employer should seek expert advice before taking a decision.

The Norwich Union offers assistance and guidance on these problems through their Pensions Consultants, men with wide experience and expert knowledge.

Where pension schemes are arranged with the Norwich Union, the Society will carry out all the negotiations necessary with the Registrar and the Inland Revenue to secure the Certificate of Non-participation permitting the firm to contract out of the State scheme.

May we arrange for one of our Pensions Consultants to discuss pensions with you?—entirely without obligation, of course.

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Company .....

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S.M.I.

Inclined shutes are arranged from the centre of the bed to the outside of the main frame for clearing croppings.

The top portion of the machine between the side frames is covered with sheet metal, concealing the drives and the pitmans. The main drive and gears are also fitted with sheet-metal guards. The main bearings, slides, etc., are lubricated with a hand-operated single-shot lubrication system. The distance between uprights is 108 in. The motor drive is for 400/440-V., 3-phase, 50-cycles supply.

Colour-corrected Furnace Observation Glasses

FOR many years steelmakers and furnacemen in this country have experienced difficulty in obtaining a uniform supply of blue glass suitable for furnace observation glasses. The blue glass formerly used has reduced the red part of the colour radiation from the inside of the furnace, but the colour was not neutralized ; consequently, disturbing blue, green or red colours, even double colours were observed which made it impossible to identify the finer details in a high-temperature furnace over long periods. For opthalmic as well as physical reasons it is an advantage to use glass which transforms the composition of the colour radiations coming through the window of the furnace so that the light colour radiated through the filter to the eye appears to approach neutral, *i.e.*, uncoloured.

Safety Products Ltd., Holmethorpe Avenue, Redhill, Surrey, have developed a range of four furnace observation glasses, 42 A DIN to 48 A DIN, with degrees of light transmission in stages for the temperature range of 1,105 to 1,890° C. It is claimed that these glasses produce the desired light density in the field of observation as well as colour-metric correction while retaining the normal resistance to heat.

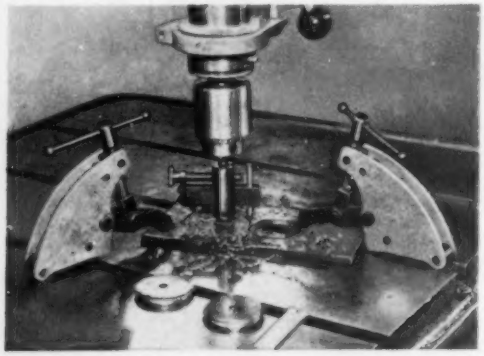
The glasses are supplied in sheet glass quality for glazing spectacles and small protective shields.

Machine Bed Clamps

A NEW type of machine bed clamp has been designed by Odoni Equipment Ltd., Salisbury House, London Wall, London, E.C.2, which should provide a simple but effective means of reducing the hazards and consequent loss of time encountered on the light machine bed.

The new clamps (Fig. 4) are sold in pairs, are of simple design and can be adapted to any T-slot. They can swivel through 360 deg. and are suitable for clamping any thickness from 0.001 to 2.25 in. and can exert a pressure of half a ton at the point of application.

Fig. 4.—Machine bed clamp



New Range of Disc Brakes for Motors

AMONG the exhibits to be shown on their stand at the Mechanical Handling Exhibition, Brookhurst Igranic Ltd., Elstow Road, Bedford, are featuring one of a new range of disc brakes designed mainly for a.c. supply machine tool and small crane motors. The brake can be arranged for flange mounting so that it can be incorporated in, or immediately adjacent to, the actual motor ; a hand release can be provided if required.

Ready-for-Use Gel Coat System

BAKELITE Ltd., 12/18, Grosvenor Gardens, London, S.W.1, have produced a new premixed gel coat system, Bakelite Resin DSR. 19142, based on high-quality general-purpose polyester resins.

It is claimed that the use of DSR. 19142 avoids the time and money consuming operation of making small quantities of gel coat mixes, and eliminates the necessity of having to dilute thixotropic concentrates. It possesses a degree of thixotropy which ensures that the gel coat will not drain from vertical or steeply inclined surfaces when it is applied in suitable thickness.

The new system has been specially designed to combine maximum ease of application with minimum risk of air bubble trapping and subsequent pin-holing. It allows the production of smooth, even gel coats which show very good wear, weather, chemical and solvent resistance. The nature of DSR. 19142 is such that a degree of flexibility and resilience is conferred upon the cured gel coat, thereby minimizing the risk of cracking and crazing.

New-Type Pedal Control

J. P. UDAL Ltd., Interlock Works, Court Road, Birmingham, 12, have developed a versatile pedal control which is claimed to reduce the effort required to operate any machine and helps eliminate operator fatigue. It also enables the operator to take up the best position to suit production conditions, cutting down fatiguing non-productive movements and assisting where bulky work-pieces are manipulated. Designed for easy toe operation, with the operator's heel resting on the floor, it can either include an air valve or an electric limit switch.

Additive for Accelerated Zinc Phosphate

THE Walterisation Co. Ltd., of Purley Way, Croydon have produced a new additive to their accelerated zinc phosphating baths, *i.e.*, the Fasbond processes, which enables degreasing and phosphating to be carried out in the one solution.

Waltersolv, as the new additive is called, consists of degreasing and emulsifying agents in solution in a high boiling point fraction derived from petroleum having a flash point of 120° C. and a boiling point of 260 to 290° C. Although the solution is only ignitible with difficulty, there is some fire hazard, particularly if spillage occurs on to an open flame and it is recommended that tanks should be heated by steam or electricity.

The general function of the new additive is that while a proportion of it is taken up by the phosphating chemical to form an emulsion, the bulk of it will float on the surface to form a blanket which prevents loss of heat and steam from the processing solution—this results in a saving in heating costs which can be as high as 75 per cent.

Because of its high boiling point, very little of the Waltersolv is lost by evaporation but replenishment of the amount removed by drag-out is necessary from time to time. In addition, as the grease removed from surfaces is absorbed by the solution, a build-up of emulsified grease and soil occurs which will necessitate discarding the whole solution periodically ; the frequency of the necessity

(*Continued in page* 318)

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to change the solution can be reduced by the prior removal of heavy deposits of oil, grease and other contaminants.

High-temperature Material

A NEW composition based on silicon nitride has been developed by the Admiralty Materials Laboratory at Holton Heath as a result of a search for stator blade materials for use in gas turbines at 1,200° C. This is thought to be an important addition to the range of high-temperature ceramics.

Silicon nitride has excellent thermal shock and oxidation resistances and adequate creep strength at 1,200°C. It is composed of cheap, non-strategic raw materials and can be formed to very close tolerances by conventional machining methods and has good mechanical strength at temperatures up to 1,200°C.

Although the ceramic was originally intended for use as a stator material in high-temperature gas turbines, it has also been found suitable for other applications, some of which are in current use, such as furnace chamber linings, shackles and components for high-temperature testing, and brazing jigs.

Adjustable Trestles

MAXIMUM safety is one of the prime objects in the design of the new General Trade Equipment adjustable trestles for working platforms (Fig. 5).

Before being brought on to the market these steel trestles were put through arduous tests in laboratories where they withstood maximum wear and tear under the worst possible conditions, and in order to ensure full stability they are fitted with special locating lugs.

Electrically welded throughout, these simple, functionally designed trestles stack flat in multiples. The main uprights are of 1¼-in. diameter steel tubing with 1-in. extending tubes and ¾-in. triangular legs. The top crossbar can be ordered in 1½-in. diameter tube or 2-in. by 1½-in. angle.

The trestles are marketed in 11 sizes ranging from a 19-in. by 33-in. extension with three boards to a 4½-ft. by 8-ft. extension with five boards. They are available from General Trade Equipment Ltd., 89-92, Seymour Place, London, W.1.

Fig. 5.—Adjustable trestle

Fig. 6.—Precision grinder No. 23OX

Precision Grinding the Joint Faces of Die Sets and Press Tools

THE Lumsden Machine Co. Ltd., of Gateshead, have added to their wide range of surface grinders, an entirely new machine known as the No. 23OX (*see* Fig. 6).

This plano-type machine not only meets the requirements of the toolroom and maintenance shops where the grinding and modifications of die-sets and tools are produced, but also enables a wide range of relatively large and complex surfaces to be precision ground. A high order of accuracy in finish, size and parallelism is obtained.

The machine is of the vertical-spindle type. The rotary table is mounted on a carriage which is reciprocated under the wheel by means of a hydraulic cylinder, giving infinitely variable speeds from 5 to 30 ft. per minute. The reversal of the table is smooth and entirely free from shock, which enables fine finishes to be obtained, while fine hand movement to the wheelhead, vertically and transversely, permits grinding close to a shoulder or a die pin or locating dowels.

The carriage, which supports the table and its driving worm and motor, slides on double vee ways, which are fully protected throughout their length. The table, which rotates on an oil bath track, can be either 30 in. or 48 in. diameter and has individual motor drive giving two speeds of 8 or 16 r.p.m.

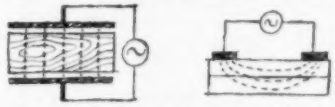
The machine base, which is a heavy box-section casting, houses the hydraulic pump and motor, the reverse and control valves and the oil tank. Robust columns support the cross rail which carries the saddle and vertical grind-

(*Continued in page* 320)

Electrical Aids in Industry *Data Sheet* **No. 10**

Dielectric Heating - 1

When an electrically non-conducting material is placed between two metal plates, called electrodes, connected to an A.C. supply, the alternating electrostatic field between the electrodes considerably speeds up the molecular movements in the material (termed a 'dielectric') as a result of which the temperature of the material under treatment rises. A similar effect is produced



where the two electrodes are positioned on the same side of the dielectric; in this case the electrostatic field between them is generally known as a 'stray' or 'fringe' field. For industrial application, the applied voltage of the order of 15,000 volts supplied by an electronic generator alternates at frequencies of some millions of cycles per second.

The amount of heat generated in the dielectric is determined by the frequency, the square of the applied voltage, the dimensions of the object and a physical property of the material termed 'loss factor' and is represented by the equation :

Power $= 1{\cdot}41\ E^2\ f.F.\ \frac{A}{t} \times 10^{-15}$ kW.

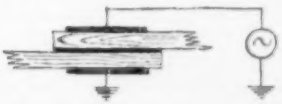
Where E = applied voltage,
f = frequency, F = loss factor.
A = area of the dielectric in square inches.
t = thickness of the dielectric in inches.
F, the loss factor, is itself equal to the expression K Cos Ø in which :
K = the dielectric constant of the material,
Cos Ø = the dielectric power factor of the material.

Therefore, 'loss factor' is a property of the material and a measure of the ease with which it can be heated by this method. Like other physical properties, it varies considerably for different substances. The equation shows that the heat generated in a dielectric is proportional to its loss factor, but the rate of rise of temperature will also depend upon its specific heat and density. The following table gives approximate values of the dielectric constant, power factor and loss factor of a few typical dielectric materials for frequencies around a million cycles a second.

MATERIAL	DIELECTRIC CONSTANT	POWER FACTOR	LOSS FACTOR
Natural Rubber	2·9	0·02	0·058
Oak, dry	3·3	0·04	0·132
P.V.C.	5·3	0·06	0·318
Nylon	3·7	0·05	0·185
Water, pure	80·0	0·03	2·40
Water, tap	80·0	0·5/5·0	40/400

The high loss factor of water means that materials which are difficult to heat when completely dry will often heat efficiently when moisture is present. The voltage must be increased towards the end of the process in some cases to remove the final moisture traces, the reduction in loss factor as the material dries out providing a safeguard against overheating.

If the workpiece is made up of a number of materials, each material will heat up uniformly but each at a rate depending upon its loss factor, thermal properties and density. The degree of temperature uniformity throughout the workpiece will then depend upon the extent to which thermal conductivity can equalise different rates of heating.



Such different rates of heating can be turned to good account in certain applications. For example, in wood glue setting, the glue lines heat up much more rapidly than the wood pieces being joined and the glue sets before the wood heats up substantially, wood having a lower loss factor than glue.

For further information get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Tel : TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available — "Induction and Dielectric Heating" is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

6776/4

ing head. The motorized head has a 12-in. hand down feed and is well supported on long slides at all positions. Thrust is taken up by spring loading and the whole head is accurately counterbalanced. Provision is made on the columns for adjustment to facilitate alignment of the wheel with the rotary table.

The saddle, which is well supported on the flat ways of the cross rail, can be cross-traversed to enable the rotary table to be used to its full capacity.

Anti-friction Shaft Bearing

AN anti-friction bearing for shafts up to 2½ in., which carry moderate loads, is provided by Fenner-Dodge Type SC ball-bearing plummer blocks. Full self-alignment is provided by the spherical outer race of the ball-bearing which fits into the spherical seat in a cast iron housing. Only non-expansion types are supplied. To exclude dust and dirt and to retain the lubricant, special seals are fitted which cannot be blown out when a grease-gun is used.

A locking-pin locates the lubrication hole and prevents rotation of the outer bearing race. This locking device is so arranged that if replacement of the ball bearing is necessary it can be removed from the housing without disturbing it from its seating.

The nine bore sizes available range from ¾ in. to 2½ in.; the makers are J. H. Fenner and Co. Ltd., Marfleet, Hull, Yorkshire.

New Design of Motor

AN addition to their range of industrial motors is announced by the Motor and Control Gear Division of Associated Electrical Industries Ltd., Rugby.

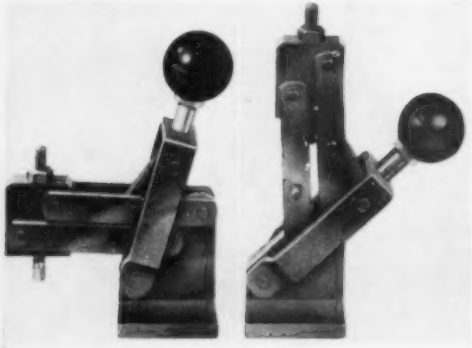
The new motor is designated Type KN-D and is of the squirrel-cage induction class, totally enclosed fan-cooled, with ribbed frame and endshields. Class "E" insulation is used, permitting a maximum temperature rise of 65° C. The machine complies electrically with B.S. 2613 : 1957 and its dimensions are such that it is completely interchangeable, rating for rating, with the ventilated (AEI Type KN-C) British Standard Dimension motor built in accordance with BS. 2960 : 1958.

The use of the improved insulation makes it possible to offer a motor of smaller dimensions at a lower price than the earlier Class "A" insulated 55° C. rise British Standard Dimension machine which it replaces.

The new motor is now available in sizes up to 7½ h.p. but at a later date the range will be extended to 40 h.p. at 1,500 r.p.m.

Figs. 7 and 8.—Vertical lift clamp

Fig. 7 *Fig. 8*



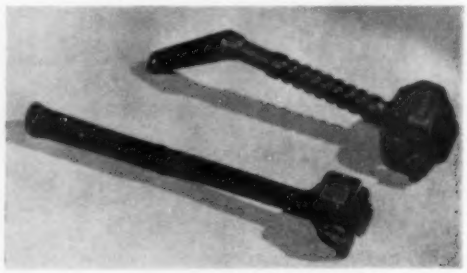


Fig. 9.—Abrasive belt dressers

Abrasive Belt Dressers

FIG. 9 illustrates the Desmond Beltbrasive dressers manufactured by The Desmond-Stephan Manufacturing Co., Ohio, U.S.A., and distributed by the Addison Tool Co. Ltd., Addison House, 28 Marshalsea Road, London, S.E.1.

The dressers are designed for removing loaded material from the faces of abrasive belt grinders, abrasive discs and pneumatic wheel grinders, and are produced in three sizes with easily changed cutters. B.C.A.-1 and B.C.A.-2, shown in the illustration, are fitted with flexible tooth cutters, face width 1½ in. and diameter 1⅝ in., and may be used for wet or dry applications; B.C.A.-1 is for use on abrasives of 200 to 300 grain-size and B.C.A.-2 for use on abrasives of 60 to 200 grain-size. B.C.A.-4 which is shown with a straight handle is provided with stiff tooth cutters, 1¼ in. in dia. and face width of ⅛ in., and is designed for use on abrasives of 60 grain-size or coarser and usually dry.

The economics of using efficient dressers is that the loading on to the abrasive of the material being ground is more detrimental to the life and efficiency of the abrasives than normal wear.

Clamp With Vertical Action

SPEED Tools Ltd., Vereker House, Gresse Street, London, W.1, have produced a new clamp in which the movement of the spindle is straight up and down to eliminate the normal arc of travel common to the general range of toggle clamps. The clamp is the model ST 210 Speetog vertical lift clamp; Fig. 7 shows the clamp just prior to final closing and illustrates the special linkage enabling the spindle to follow a more or less vertical path throughout its travel, in fact the closing movement of ¼ in. is straight down.

Fig. 8 shows the clamp in the fully opened position wherein it can be seen that the spindle in its carrying block still retains its vertical position; the illustration also indicates the small amount of room required to operate the clamp.

The clamp enables the spindle to be entered into or withdrawn from a locating hole, so that components may be accurately located and clamped simultaneously. Similarly, the clamp block which carries the spindle, may be shaped to locate contours so that the lateral position of the component may be controlled whilst it is being clamped.

The equipment is of particular advantage for clamping plastics and fragile material, since with normal toggle clamps where the clamping arm descends in an arc, the spindle inevitably strikes at one point only immediately before the final squeeze is applied.

"RIVET" YOUR ATTENTION

on these pertinent answers to your fastening problems. They tell you of the many advantages to be gained by using 'Pop' rivets for every form of assembly.

TUCKER 'POP' RIVETS

Q What is a 'Pop' rivet?

A *It is a tubular rivet assembled on a headed steel mandrel.*

Q In what sizes and materials are 'Pop' rivets supplied?

A *From $\frac{1}{32}$" to $\frac{1}{4}$" dia., in aluminium alloy, mild steel and monel for riveting up to $\frac{1}{2}$" thickness.*

Q What is the operating principle?

A *By means of hand or pneumatic tools the mandrel is drawn through the rivet, forming a head on the blind side and at the same time clenching the sheets together. When the joint is tight the mandrel breaks leaving the rivet head fully formed.*

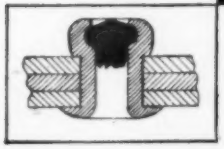
Q What are the advantages of the 'Pop' rivet?

A *Only one side of the structure to be riveted need be accessible, only one operator required, ease and speed in setting, combination of lightness with strength, foolproof and gradual setting action which eliminates any possibility of damage or distortion of the structure.*

Q How do 'Pop' rivets cut costs?

A *They can be set at speeds in excess of 20 per minute by one unskilled operator.*

They facilitate riveting in hitherto unknown inaccessible positions, thereby reducing design costs.



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Telephone: BIRchfields 4811 (9 lines) **Telegrams: EYELETS, BIRMINGHAM**

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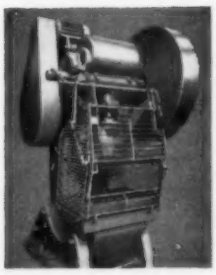

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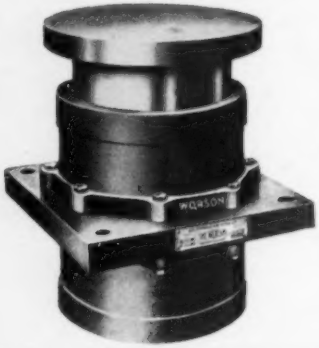

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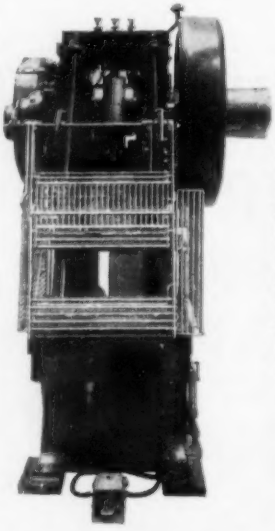

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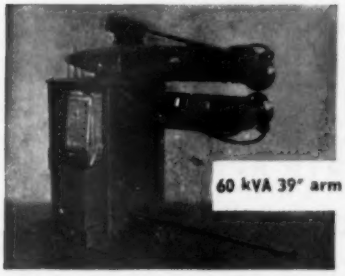

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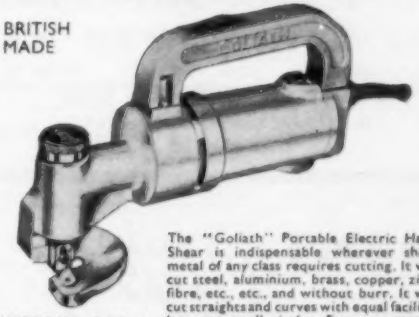

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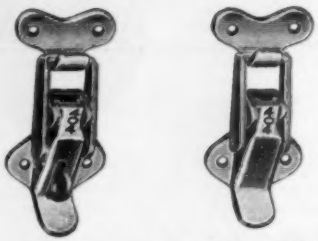

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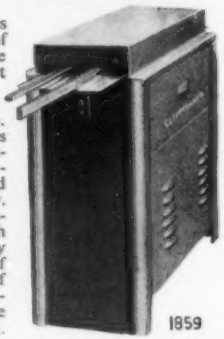

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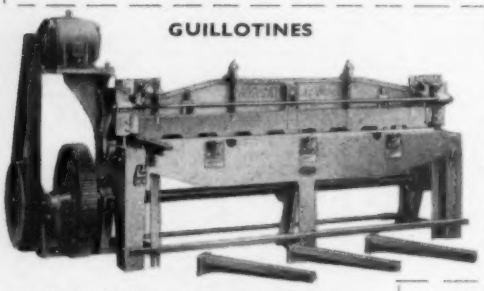

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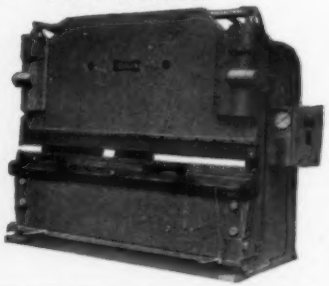

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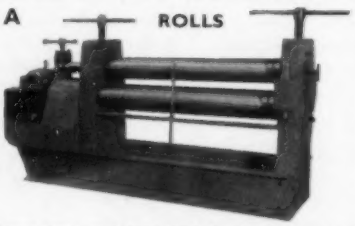

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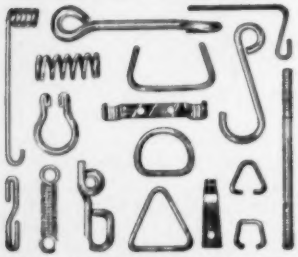

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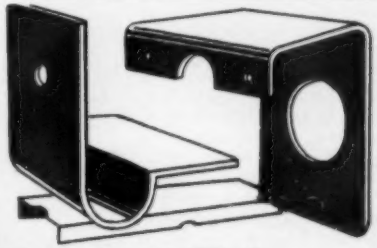

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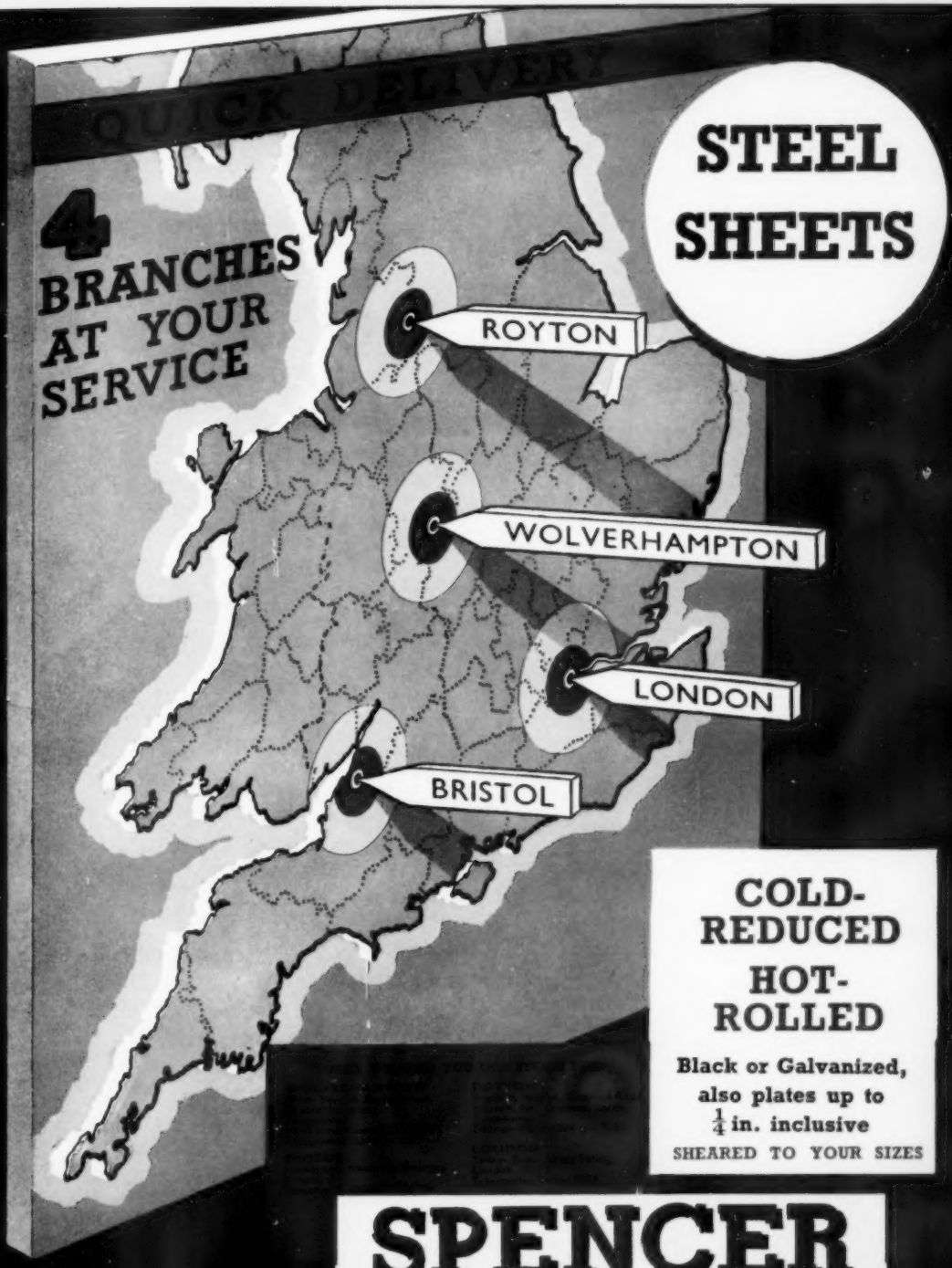
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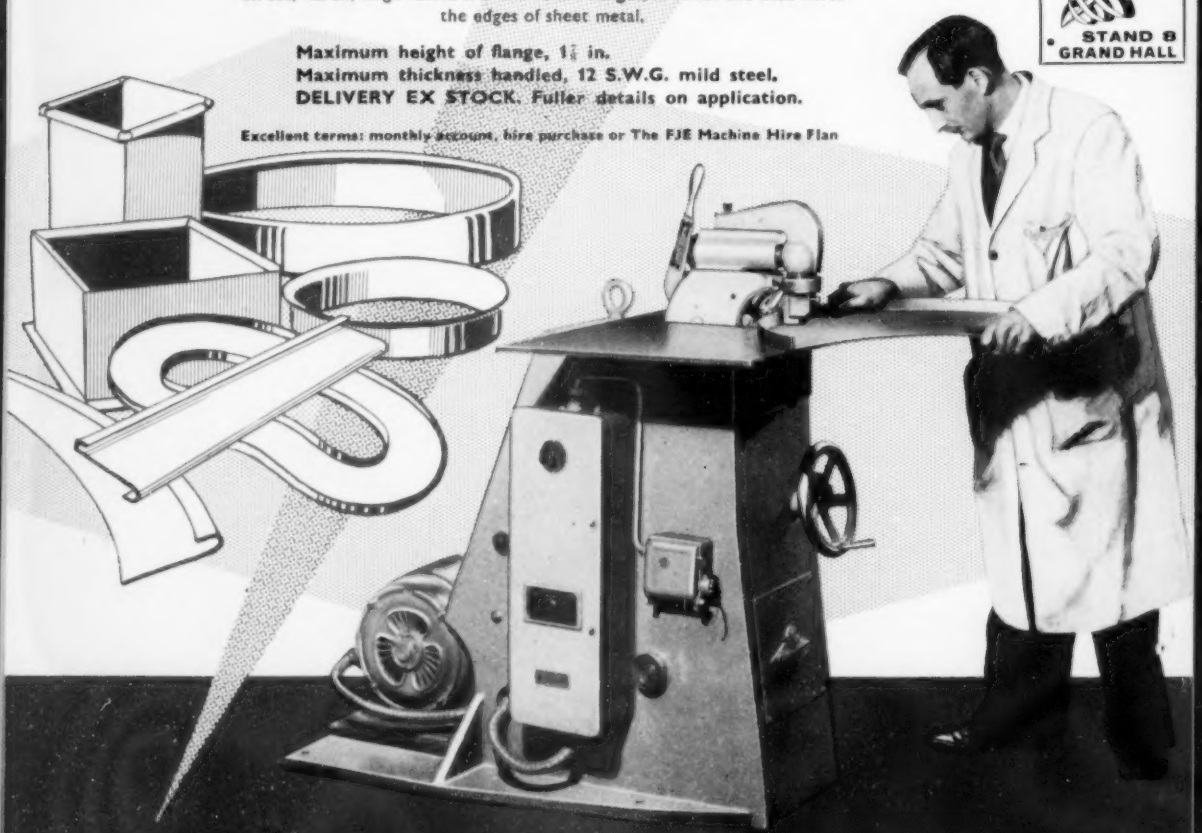

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